

Wigwam River Juvenile Bull Trout and Fish Habitat Monitoring Program

Monitor and Protect Wigwam River Bull Trout - Koocanusa Reservoir

Annual Report
2001



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Bonneville Power Administration
P.O. Box 3621
Portland, Oregon 97208

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

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B O N N E V I L L E P O W E R A D M I N I S T R A T I O N



Wigwam River Juvenile Bull Trout and Fish Habitat Monitoring Program: 2001 Data Report.



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Funded by: **Monitor and Protect Bull Trout for Koocanusa Reservoir**
BPA Project Number 2000-004-01,
Bonneville Power Administration, Fish and Wildlife Program
P.O. Box 3621, Portland, OR 97208

Executive Summary

The Wigwam River juvenile bull trout and fish habitat monitoring program is a co-operative initiative of the British Columbia Ministry of Water, Land, and Air Protection and Bonneville Power Administration. The Wigwam River has been characterized as the single most important bull trout spawning stream in the Kootenay Region. This report provides a summary of results obtained during the second year (2001) of the juvenile bull trout enumeration and fish habitat assessment program. This project was commissioned in planning for fish habitat protection and forest development within the upper Wigwam River valley. The broad intent is to develop a better understanding of juvenile bull trout and Westslope cutthroat trout recruitment and the ongoing hydrologic and morphologic processes in the upper Wigwam River, especially as they relate to spawning and rearing habitat quality.

Five permanent sampling sites were established August 2000 in the Wigwam river drainage (one site on Bighorn Creek and four sites on the mainstem Wigwam River). At each site, juvenile (0^+ , 1^+ and 2^+ age classes) fish densities and stream habitat conditions were measured over two stream meander wavelengths.

Bull trout represented 95.1% of the catch and the mean density of juvenile bull trout was estimated to be 20.7 fish/100m² (range 0.9 to 24.0 fish/100m²). This compares to 17.2 fish/100m² (+20%) for the previous year. Fry (0^+) dominated the catch and this was a direct result of juvenile bull trout ecology and habitat partitioning among life history stages. Site selection was biased towards sample sites which favored high bull trout fry capture success.

Comparison of fry density estimates replicated across both the preliminary survey (1997) and the current study (Cope and Morris 2001) illustrate the stable nature of these high densities. Bull trout populations have been shown to be extremely susceptible to habitat degradation and over-harvest and are ecologically important as an indicator of watershed health. As such, the upper Wigwam River watershed remains relatively pristine, and maintains high water quality and high habitat capability. Conservative angling regulations have been successful in preventing over-harvesting. To date, the forest licensee has harvested 36% of the allowable cut identified in the forest development plan.

Acknowledgements

Funding was provided by the Bonneville Power Administration (BPA) under the umbrella project "Monitor and Protect Bull Trout for Koocanusa Reservoir"; BPA project Number 2000-004-01. The authors wish to acknowledge all the individuals that have worked over the past years to improve the knowledge about the Wigwam River bull trout. Their contributions and on-going monitoring results are greatly appreciated. Angela Prince, Glenn Smith, Leanne Colombo of Westslope Fisheries contributed to data collection.

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1 Introduction

The Wigwam River bull trout (*Salvelinus confluentus*) and fish habitat monitoring program is a trans-boundary initiative implemented by the British Columbia Ministry of Water, Land, and Air Protection (MWLAP), in cooperation with Bonneville Power Administration (BPA). The Wigwam River is an important fisheries stream located in southeastern British Columbia that supports healthy populations of both bull trout and Westslope cutthroat trout (Figure 1.1). This river has been characterized as the single most important bull trout spawning stream in the Kootenay Region (Baxter and Westover 2000, Cope 1998). In addition, the Wigwam River supports some of the largest Westslope cutthroat trout (*Oncorhynchus clarki lewisi*) in the Kootenay Region. These fish are highly sought after by anglers (Westover 1999a, 1999b).

Bull trout populations have declined in many areas of their range within Montana and throughout the northwest including British Columbia. Bull trout were blue listed as vulnerable in British Columbia by the B.C. Conservation Data Center (Cannings 1993) and although there are many healthy populations of bull trout in the East Kootenays they remain a species of special concern. Bull trout in the United States portion of the Columbia River were listed as threatened in 1998 under the Endangered Species Act by the U.S. Fish and Wildlife Service. The upper Kootenay River is within the Kootenai sub-basin of the Mountain Columbia Province, one of the eleven Eco-provinces that make up the Columbia River Basin. MWLAP applied for and received funding from BPA to assess and monitor the status of wild, native stocks of bull trout in tributaries to Lake Koocanusa (Libby Reservoir) and the upper Kootenay River. This task is one of many that were undertaken to "Monitor and Protect Bull Trout for Koocanusa Reservoir" (BPA Project Number 2000-04-00).

1.1 Objectives

Five permanent sampling sites were established in the Wigwam river drainage in August 2000 (one site on Bighorn Creek and four sites on the mainstem Wigwam River). At each site, juvenile fish densities and stream habitat conditions have been measured annually. The broad intent of this project was to develop a better understanding of inter-annual variation in juvenile bull trout and Westslope cutthroat trout recruitment and the ongoing hydrologic and morphologic processes in the upper Wigwam River, especially as they relate to spawning and rearing habitat quality and timber harvest development. The August 2001 sampling program represents a continuation of the study into year 2.

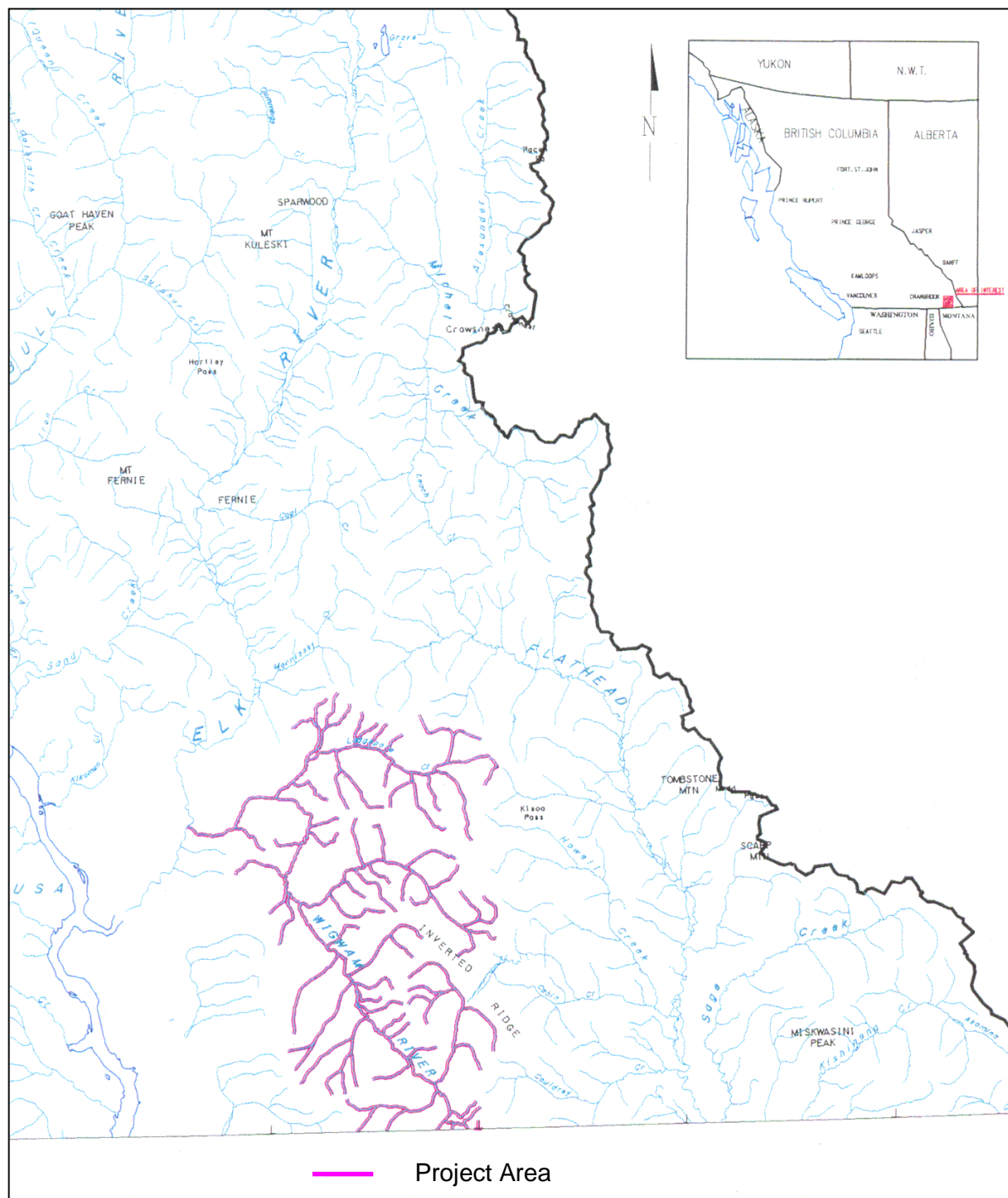


Figure 1. Location of Wigwam River Study Area

1.2 Study Area

The Wigwam River originates in the Rocky Mountains within the state of Montana and flows northwest between the Galton and MacDonald ranges in British Columbia for approximately 47 km until it empties into the Elk River, a tributary to Lake Koocanusa (Figure 1.1). The headwaters of the Wigwam drainage originate at an elevation of 2,135 m and declines to 763 m. The Wigwam River valley is characterized by four biogeoclimatic zone variants; Kootenay dry mild interior Douglas-fir, dry cool montane spruce, Kootenay moist cool interior cedar hemlock, and dry cool Engelmann spruce sub-alpine fir (Braumandl and Curran 1992).

The flow regime of the Wigwam River is comparable to most interior systems with high annual run-off reaching it's peak in May (peak mean daily discharge $74 \text{ m}^3/\text{s}$ on 24 May 2000) and expected low flows in late fall and winter ($2.1 \text{ m}^3/\text{s}$; Prince and Cope 2001). Freeze up generally occurs in mid to late November; however, areas of groundwater infiltration remain open in most years. The temperature signature recorded in the mainstem Wigwam River in the vicinity of the spawning grounds was indicative of groundwater and daily maximum temperatures within the upper Wigwam River do not exceed $14.5 \text{ }^\circ\text{C}$ (Prince and Cope 2001, 2000).

The upper reaches of the Wigwam River occupy a glacial outwash channel that is bounded by glacial till terraces and silt seams. The occurrence of lacustrine silt deposits overlain by highly permeable glacial till within adjacent terraces has contributed to a predominance of sub-surface flow that reaches the mainstem as groundwater. The influence of groundwater has been a large factor in the maintenance of cool stream temperatures and annual low flows (Prince and Cope 2000, 2001). A number of natural disturbance events over time appear to have contributed a substantial volume of coarse sediment to the river including: wildfires in the 1930's, a slide in 1993, and the 1995 flood event thought to occur every 100 to 200 years (Oliver and Cope 1999). Sediment aggradation throughout a broad, alluvial floodplain is associated with channel-confining bedrock outcrops. The combination of frequent lateral migration and erosion of adjacent terraces and coarse sediment delivery to the mainstem river has created a braided channel comprised of sorted gravels and cobbles that provide prime spawning habitat for bull trout (Oliver and Cope 1999). The provision of suitably sized bed materials ($<20 \text{ mm}$) in a low gradient, low water velocity location with

associated groundwater have been identified as repeating patterns of preferred bull trout spawning habitat (McPhail and Baxter 1996).

1.2.1 Forest Development Status

Forest harvesting and accompanying road development in the Wigwam basin have, to date, been undertaken primarily in Montana, where approximately 20% of the watershed was logged (with extensive road network) in the 1950's and 1960's with subsequent 'green-up' ongoing to the present day (Anon. 1999). In the Canadian portion of the watershed, logging has been limited to the Rabbit Creek sub-basin (< 100 ha), with some helicopter logging in the 1990's near the confluence of the Wigwam River with the Elk River. Conventional logging occurred approximately 20 years ago in the vicinity of the confluence with the Elk River, and in the Bighorn Creek sub-basin. British Columbia Watershed Restoration Program (WRP) activities have been on-going within the Bighorn Creek watershed since 1995 (Cope 2000).

The original Tembec Forest Development Plan (FDP; Tembec 1999) has gone through several iterations in response to stakeholder concerns. The current plan (commonly referred to as amendment 5) calls for logging a total of 657.3 ha (0.89% of the entire watershed) or 163,816 m³ of harvest volume, over a three to four year period after which no further harvesting is planned for 20 years. Forest development activities for the 2000 works windows included the construction of approximately 30 km of mainline Forest Service Road, spur roads, and the installation of five bridges; including one full span crossing of the upper Wigwam River. Harvesting commenced in December 2000, and as of 10 November, 2001 a total of 36% (231.5 ha) of the planned harvest volume was harvested. Lodgepole pine is the predominant species being harvested. All cutblocks are on glacial till terraces in the valley bottom and are to be clear-cut.

Forest development plans for the Wigwam River watershed have come under considerable scrutiny because of potential impacts to bull trout habitat. The issues have largely centered on block size, water temperature, increased sediment yield, and base flow levels in the mainstem river. The creation of extensive openings in a largely even-aged, lodgepole pine forest are intended to mimic a natural stand initiating event consistent with the valley's wildfire history. The size of the proposed clear-cuts however, are perceived to alter basin hydrology, affect the annual flow regime (both peak and base flows) and encourage surface erosion that could lead to fine sediment delivery.

1.2.2 Fisheries Resource Status

When compared to other bull trout systems, it can be argued that the Wigwam River may be the most prolific bull trout population in the species distribution range. Juvenile densities are some of the highest densities reported within the literature (Cope 1998) and spawning escapements consistently exceed 1,000 fish (Baxter and Westover 2000). Baxter and Westover (2000) provide a thorough review of the biology, population status, and scientific studies to date for this population. The principle concerns for the Wigwam River population center around the potential impacts of forest harvesting. Bull trout are adapted to cold water temperatures and thrive in waters that are too cold, unproductive or too steep in gradient for other fish. Bull trout are not found in streams where maximum monthly water temperatures exceed 18°C and are most abundant where water temperatures are 12°C or less (Goetz 1989, Ford *et. al.* 1995, McPhail and Baxter 1996, Buchanan and Gregory 1997). This preference for cooler water manifests in the frequent association of bull trout with cold perennial springs (Oliver 1979, Goetz 1989, McPhail and Baxter 1996, Buchanan and Gregory 1997). In general, the species does not occur in high densities, a tendency that is partly due to the life-history strategy and the environment in which they live. Low population densities, slow growth, delayed maturation and high quality habitat requirements (water temperatures < 14°C, spawning gravel with low % fines) make bull trout sensitive to habitat degradation and over-harvesting (Goetz 1989, Fraley and Shepard 1989, Ratliff *et. al.* 1996, Ford *et. al.* 1995, McPhail and Baxter 1996).

Westslope cutthroat trout are also typical of cold, nutrient poor streams (Liknes and Graham 1988). The Wigwam River population of Westslope cutthroat trout contains appreciable numbers of large individuals with adults attaining 450 mm fork length (Westover and Conroy 1997). Although the distribution and abundance of Westslope cutthroat trout have drastically declined from its historic range during the last 100 years, the abundance and size of the current Wigwam River population may be attributed to the combination of special regulations designed to limit harvest and high quality available habitat.

2 Methods

Five permanent sampling sites were established in the Wigwam river drainage in August, 2000 (reaches 5, 6, 7, and 9 of the Wigwam River, and reach 1 of Bighorn Creek, Appendix A, 1:50,000 TRIM map). Sampling sites were a minimum of 20 channel widths in length or a distance equal to two stream meander wavelengths. At each site the following reference points were permanently established, geo-referenced and marked with a combination of metal tree tag, tree blaze, fluorescent tree paint, and flagging tape:

- Upstream and downstream elevation benchmarks. Elevation benchmarks were also represented by a lag bolt imbedded in the base of a large, stable, riparian tree,
- Upstream and downstream limits of the longitudinal survey,
- Riffle and pool cross-sectional reference points, and
- Electrofishing habitat units.

The following methods outline the specific assessments completed at each of the five permanently established sites.

2.1 Juvenile Enumeration

Estimates of juvenile fish density (number of fish/100 m²) were determined using closed, maximum-likelihood removal estimates (Riley and Fausch 1992). For each site, three habitat units (riffle, pool and run) were individually sampled for fish densities over a minimum of 100 lineal meters and/or 500 m². This methodology allows for habitat unit comparisons as well as reach comparisons through pooling of habitat units to obtain a mean. A Smith-Root Mark 12POW backpack electroshocker was used for successive depletions within each closed sample unit. Although bull trout are the main focus of this project, densities of all fish captured were reported.

All sampling was conducted at the permanent stations established in 2000. The project biologist and lead technician were also members of the original enumeration crew further ensuring consistency and minimization of sampler bias.

Catch results from individual habitat units were summed, by pass, at each representative reach location. These results were then used to estimate the number of fry (0⁺ age class) and juveniles (1⁺ and 2⁺ age classes) within the composite enclosure area. Population estimates were calculated using the "Microfish" software package (Van Deventer and Platts

1990). Population estimates and their 95% confidence interval were then reported as a standard numerical density (number fish/100 m²).

2.2 Fish Habitat Assessment

A standard suite of habitat parameters were collected using the Resource Inventory Committee (RIC) approved Fish Habitat Assessment Procedures (FHAP), Level 1, Form 4 - Habitat Survey Data Form (Johnston and Slaney 1996). The level 1 FHAP a purposive field survey of current habitat conditions for the target species in select reaches. This form has been developed for interpretation of habitat sensitivity and capability for fish production and includes prominent physical features such as pool and riffle ratios, residual pool depths, channel stability, flood indicators, cover components, abundance of large woody debris (LWD), and riparian vegetation.

Following methods described in Rosgen (1996) the following measurement of channel bed, channel bank and fish habitat parameters were also completed again in 2001:

- A longitudinal Profile (two stream meander wavelengths) of the stream bed following the thalweg of the stream channel and water surface (slope);
- Stream cross-sections on both a riffle and pool segment;
- Modified Wolman pebble count, and
- Stream discharge and bank full width.

Geomorphic surveys were completed using a level (Topcon AT-G7 Auto Level) and standard differential hydrometric survey techniques (Anon. 1998). Benchmarks permanently established in 2000 were used. A differential loop was used to accurately determine benchmark elevations. In the previous sampling year, a laser level (Laser plane 220 leveling station and target rod) was used for the survey. The laser level may not be as accurate as the Auto level over long distances and inclement weather conditions because of the refraction of the laser beam over the distance. Use of the Topcon Auto Level should result in a more accurate determination of benchmark elevations. The UTM coordinates were overlain on the digital NAD 83 Forest Cover TRIM Sheet and the elevation data corrected to this datum. At 10m intervals, following the thalweg of the stream channel, the elevation of the stream bed and the water surface was surveyed over the length of the study area. All stream and habitat unit gradients were calculated from differences in water surface elevation. Cross sectional profiles were surveyed at 1 m intervals and extended

5m beyond the bankfull width. The elevation of the bankfull channel was also noted at each cross section location. All survey loops were closed and error levels expressed to ensure quality control.

Channel bed material characterization employed the modified Wolman method outlined in Rosgen (1996). Briefly, this procedure uses a stratified, systematic sampling method based on the frequency of riffle/pools and step/pools occurring within a channel reach that is approximately 20-30 bankfull channel widths in length (or two meander wavelengths). The modified method adjusts the material sampling locations so that various bed features are sampled on a proportional basis along a given stream reach. In total, 10 transects are established and ten substrate particles are selected at systematic intervals across the bankfull channel width, for a total sample size of 100. The intermediate axis of the particle was measured such that the particle size selected would be retained or pass a standard sieve of fixed opening. The composite particle distribution was used to represent the site. To avoid potential bias, the actual particle was selected on the first blind touch, rather than visually selected.

Stream discharge was estimated at each location using a Price 1210AA velocity meter and wading rod calibrated bi-annually by the National Calibration Service of the National Water research Institute. All methods meet national and provincial standards and have demonstrated precision levels of less than +/- 5% (Prince and Cope 2000, 2001).

3 Results

The upper and lower geo-reference points (uncorrected) for each sample site are summarized below in Table 1. For the corrected UTM coordinates see the attached 1:50,000 TRIM map (Appendix A). The corresponding site numbers of the preliminary sampling program (Cope 1998) and MWLAP Environmental Monitoring System (EMS) sites (Prince and Cope 2000, 2001) were also included for reference between these complimentary monitoring programs. Sample sites established in the 2000 sampling year (Prince and Cope 2001) in reaches five, six, seven, nine of the Wigwam river and reach one of Bighorn Creek were again sampled in August, 2002.

Additional background data of varying levels of applicability and accuracy (*i.e.* previous streambed and cross-sectional surveys, pebble counts, water quantity and quality data) can be accessed through the EMS data storage initiative (MWLAP, Nelson, B.C.) and the British Columbia WRP program (MWLAP, Cranbrook, B.C.).

Table 1. Schedule of program field components for the Wigwam River bull trout and fish habitat monitoring program, 2000-2001.

| Program Component | Date | |
|--|----------------------------|-----------------------------|
| | Year 1 (2000) | Year 2 (2001) |
| Establishment of Permanent Sample Sites | August 9 – 14 | |
| Juvenile Fish Density Sampling | August 9 – 14 | August 3-9 |
| Level 1 FHAP Form 4 Measurements and Channel Surveys | September 20– October 4 | September 14 – October 5 |
| Aerial Reconnaissance Survey (Channel Dewatering, Groundwater Influence, Forest Development) | January 22 | |

Table 2. Summary of permanently established bull trout and fish habitat sample sites within the Wigwam River study area and associated site designations for on-going and previous surveys conducted in the immediate vicinity.

| Sample Site | UTM (Zone.Easting.Northing) | 1997 Site No. ¹ | EMS No. ² | Additional Habitat Data ³ |
|----------------------------|--|----------------------------------|----------------------|--|
| Wigwam R. Reach 5 Site 1 | 11.648335.5449685 11.648110.5449910 | 2 | E238242 ^a | |
| Wigwam R. Reach 6 Site 2 | 11.653886.5441349 11.653802.5441896 | 4 & 5 ^b | | CS1 |
| Wigwam R. Reach 7 Site 3 | 11.655471.5438625 11.654977.5439074 | 6 & 7 | E238246 | |
| Wigwam R. Reach 9 Site 4 | 11.661031.5432738 11.660942.5432911 | | E238250 | CS2 |
| Bighorn Cr. Reach 1 Site 1 | 11.648335.5449685 11.649089.5449439 | 13 ^c | | WRP1 |

¹ – Site numbers from preliminary bull trout and fish habitat monitoring program (Cope 1998). Data includes juvenile enumeration, RIC inventory site card, pebble count and discharge estimation.

² – MWLAP EMS site numbers from ongoing upper Wigwam River water quantity and quality inventory project (Prince and Cope 2000, 2001). Data includes water quantity and quality monitoring data.

³ – CS1 and CS2 site numbers from upper Wigwam River water quantity and quality inventory project (Prince and Cope 2000). Data includes FHAP Form 4, longitudinal and cross-sectional profiles, pebble counts and discharge estimation. WRP1 represents Watershed Restoration Program level II FHAP longitudinal (900 lineal meters) and cross-sectional profiles (n=11) (Cope and Prince 2000).

^a – Hydrometric and automated water quality grab station located 1 km upstream.

^b – Site 4 was 200 m downstream (dewatered due to down-cutting) and Site 5 was 400 m upstream.

^c – Site 13 was 300 m upstream.

3.1 Juvenile Fish Sampling

3.1.1 Species Composition and Distribution

In total, 14 habitat units were sampled across five reaches (36,450 seconds of backpack electrofishing effort over 2,502 m²; Appendix B). In year 1 effort was 41,454 seconds over 2,599 m². Both bull trout and Westslope cutthroat trout were captured in all reaches sampled; Westslope cutthroat trout were captured in all reaches except for Reach 6. A total of 470 fish were captured within the Wigwam River and Bighorn Creeks during the sample period 3 -9 August 2001 (as compared with 419 in 2000 – Prince and Cope 2001). Bull trout were the dominant species encountered, representing 95.1% (n = 447) of the total catch. The remaining 4.9% of the total catch was represented by Westslope cutthroat trout (n = 23). Bull trout fry were the target species and life stage and as such, the catch composition reflects bias associated with site selection for this capture target. Rocky mountain whitefish (*Prosopium williamsoni*) and rainbow trout (*Oncorhynchus mykiss*) have been reported in lower reaches and were not encountered in the summer 2001 sampling program.

3.1.2 Bull Trout

In total, 447 bull trout were captured and sampled for life history information (Table 3.3). All captured bull trout were juveniles and ranged in age class from 0⁺ to 1⁺ (Figure 3.1). These fish ranged in fork length from 35 mm to 112 mm and the modal class, in 10 mm intervals, was 51-60 mm. This size class represents the young-of-the-year cohort (fry, 0⁺). The relative proportions of age classes comprising the total bull trout catch were 95.1% fry (0⁺) and 4.9% (1⁺). Mean fork lengths of each age class (estimate) were 50.7 (0⁺) and 99.7 (1⁺) mm. The corresponding mean weights for bull trout age classes were 1.5 and 10.7 g respectively (Table 3.3). The growth rate of juvenile bull trout in the Wigwam River study area was described by the equation:

$$\text{Log}_{10}\text{Weight} = -4.6343 + 2.7971 \text{ Log}_{10}\text{Length (Figure 3.2).}$$

Mean density of juvenile bull trout (ages 0⁺ to 1⁺) was estimated to be 20.7 fish/100m² with a range of 0 to 24.0 fish/100m² (Appendix B). Fry (0⁺) abundance represents the 2000 brood year egg-to-fry recruitment and mean density was estimated to be 18.1 fry/100m² ranging from 5.4 to 28.6 fry/100m² (Table 3.4). The small increase in estimated fry density resulted from a large increase in Bighorn Creek bull trout fry densities (Table 3.4). Trends

in abundance appeared to be related to proximity to spawning areas, bed material size, water depth, cover and macro-habitat type sampled (i.e. glide margin).

Bull trout captures of the 1⁺ age class were far less abundant than those of fry. Captures were not sufficient to generate density estimates. Low densities were largely due to electrofishing capture inefficiencies

Table 3. Summary of fork length and weight data, by estimated age cohort, collected from bull trout captured within the Wigwam River drainage, 3 - 9 August 2001.

| | Age-Group | |
|-----------------------|----------------|----------------|
| | 0 ⁺ | 1 ⁺ |
| Mean Fork Length (mm) | 50.7 | 99.7 |
| Standard Error | 0.25 | 2.0 |
| Range | 35-66 | 79-112 |
| N | 425 | 22 |
| Mean Weight (g) | 1.5 | 10.7 |
| Standard Error | 0.026 | 0.93 |
| Range | 0.4-4 | 5.8-16.4 |
| N | 361 | 13 |

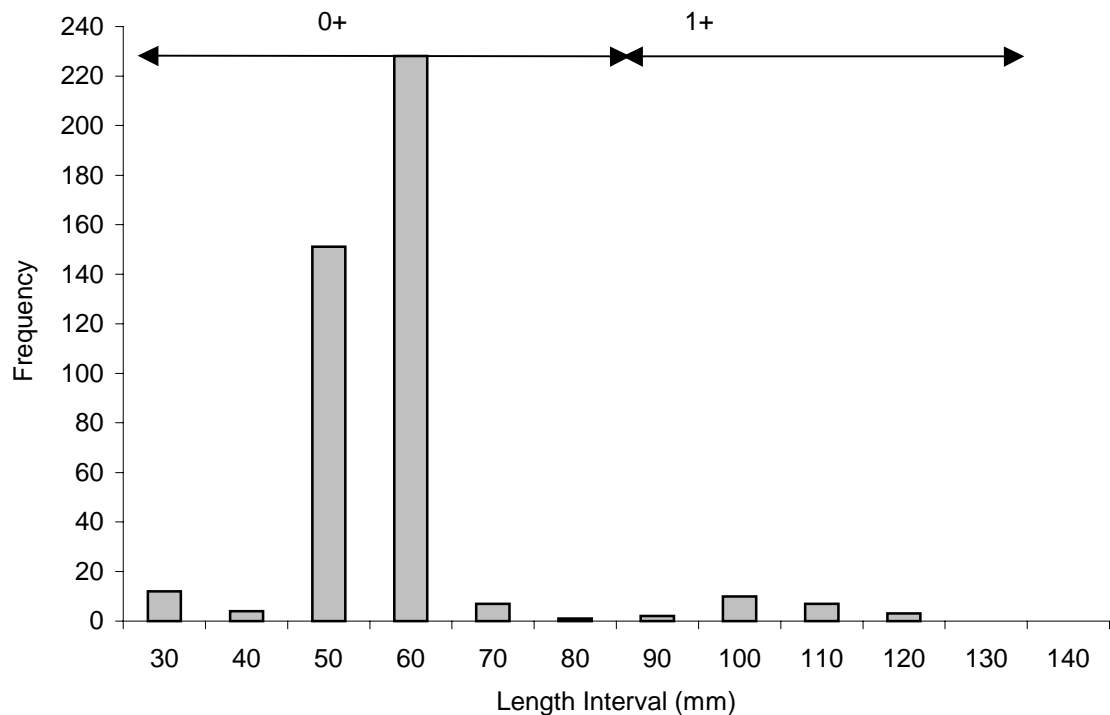


Figure 2. Length frequency distribution and estimated age cohorts for Wigwam River juvenile bull trout (0⁺ to 2⁺ age classes).

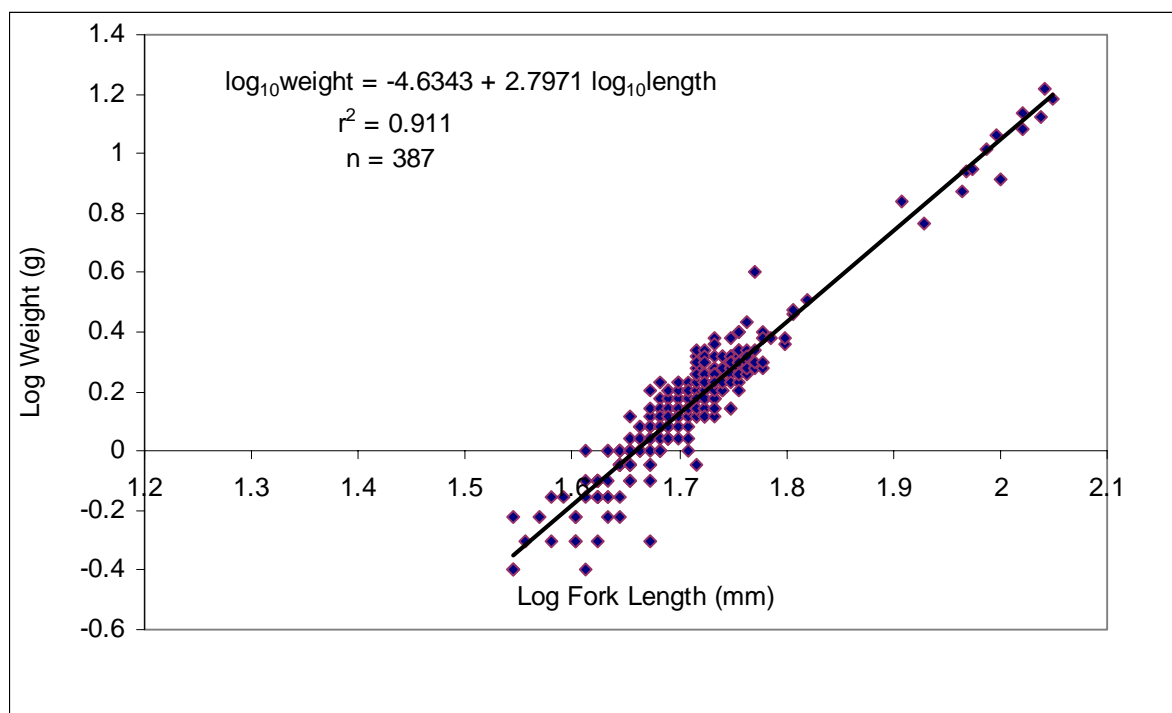


Figure 3. Length-weight regression for bull trout captured within the upper Wigwam River watershed, - August 2001.

Table 4. Mean density estimates (+/- 95% confidence interval) for bull trout fry within the upper Wigwam River permanent sample sites, 9 – 14 August 2000, 3 – 9 August 2001.

| Bull trout sample site location | Density Estimate: | |
|---------------------------------|---|--------------------|
| | Number of fry/100m ² (+/- 95% confidence interval) | |
| | August 2000 | August 2001 |
| Wigwam River - Reach 5, Site 1 | 17.1 (14.7 – 19.8) | 16.7 (14.6 – 19.3) |
| Wigwam River - Reach 6, Site 2 | 26.9 (23.3 – 30.4) | 25.7 (22.0 – 29.4) |
| Wigwam River - Reach 7, Site 3 | 16.4 (16.0 – 17.3) | 18.6 (15.3 – 23.1) |
| Wigwam River - Reach 9, Site 4 | 9.2 (8.6 – 10.5) | 5.8 (5.4 – 6.9) |
| Bighorn Creek – Reach 1, Site 1 | 15.6 (10.5 – 24.1) | 32.5 (28.6 – 36.4) |

associated with juvenile bull trout ecology and habitat partitioning among life history stages. Site selection was biased towards electrofishing sample sites which favored high bull trout fry capture success. Such sites typically have lower 1⁺ and 2⁺ age class bull trout densities.

3.1.3 Westslope Cutthroat Trout

In total, 23 Westslope cutthroat trout were captured and sampled for life history information (Table 3.5). Cutthroat trout ranged in age from 0⁺ to 1⁺ indicating the primary use of sampled habitat was by rearing juveniles. Cutthroat fork lengths ranged from 21 mm to 63 mm. Mean fork length was 24.4 (0⁺) and 79.7 (1⁺) mm. The modal length, in 10 mm intervals, was 21-30 mm and the length-frequency histogram illustrates the fry (0⁺) life-stage dominated the catch (Figure 3.3). The relative contribution to the catch was 73.9% fry and 26.1% (1⁺). The corresponding mean weights were 0.22, and 5.9 g, respectively (Table 3.5). The growth rate of Westslope cutthroat trout in the Wigwam River study area was described by the equation:

$$\text{Log}_{10}\text{Weight} = -2.7142 + 1.8842 \text{Log}_{10}\text{Length} \text{ (Figure 3.4).}$$

Table 5. Summary of fork length and weight data, by estimated age cohort, collected from Westslope cutthroat trout captured within the Wigwam River drainage, - August 2001.

| | <i>Age-Group</i> | |
|-----------------------|------------------|----------------|
| | 0 ⁺ | 1 ⁺ |
| Mean Fork Length (mm) | 24.4 | 79.7 |
| Standard Error | 0.74 | 3.25 |
| Range | 21-32 | 63-92 |
| N | 13 | 10 |
| Mean Weight (g) | 0.22 | 5.9 |
| Standard Error | 0.034 | 0.6 |
| Range | 0.1-0.4 | 2.7-9.1 |
| N | 13 | 10 |

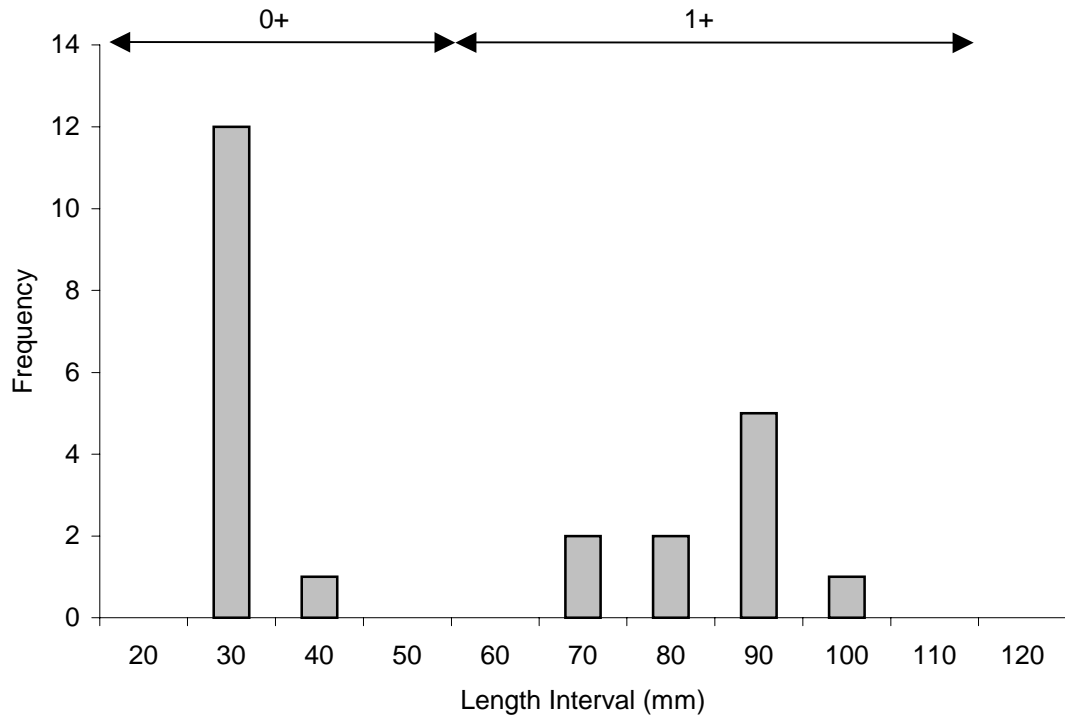


Figure 4. Length frequency distribution and estimated age cohorts for Wigwam River Westslope cutthroat trout juveniles.

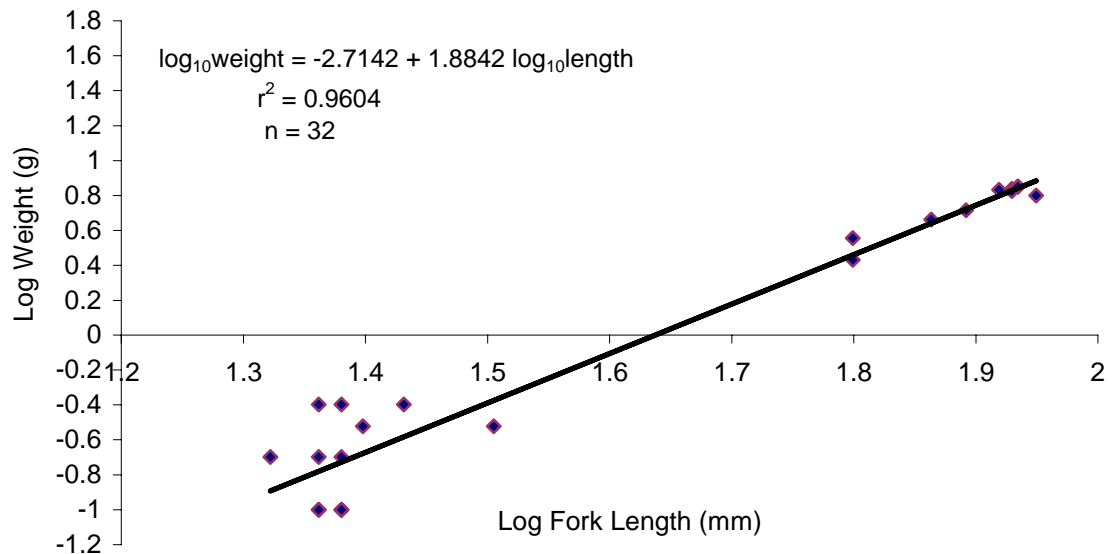


Figure 5. Length-weight regression for Westslope cutthroat trout captured within the upper Wigwam River watershed, 3- 9 August 2001.

Westslope cutthroat trout captures were not sufficient to generate density estimates (Appendix B). Low densities (mean density = 0.8 fish/100 m²) resulted in low precision (95% confidence interval 0.5 to 1.6 fish/100 m²). This was generally due to either; a non-descending removal pattern, all fish captured in a single pass, or no captures. Maximum likelihood estimation was not possible under these conditions.

3.2 Physical Habitat Monitoring

3.2.1 Water Temperature and Discharge

Discharge estimates within the upper Wigwam River ranged from 0 to 3.12 m³/s (Table 3.6). Mean monthly discharge in 2001 was significantly lower from April to November than during the same period in 2000 (Prince and Morris 2002). Discharge at the upper Wigwam River hydrometric station (reach five) during fish sampling (3 – 9 August) ranged from 2.94 to 4.86 m³/s (mean = 3.61 m³/s) for the month of August, compared with 3.86 to 6.93 m³/s (mean = 5.16 m³/s) for the month of August, 2000. The lowest discharge was observed for reach seven, which was observed dewatered on 24 August (Prince and Morris 2002; Appendix A). Similar to observations made in the previous sampling (Prince and Cope 2001). Anecdotal reports have suggested this reach dewatered in low water yield years. This was the second annual observation of this event and was attributed to low snow pack and significantly lower water yield resulting in decreased groundwater recharge (Cope and Morris 2001). The relationship between river stage at this location and the hydrometric station below the primary spawning grounds are represented in Figure 3.6.

Table 6. Summary of water temperature, mean velocity, and discharge measurements for the Wigwam River fish habitat monitoring sites.

| Date | Stream | Reach | Site | Discharge (m ³ /s) | Mean Velocity (m/s) | Water Temp. (°C) |
|----------|---------|-------|------|----------------------------------|---------------------------|-------------------------------------|
| 3 Oct. | Wigwam | 5 | 1 | 3.12 | 0.35 | 13.2 ^a /8.0 ^b |
| 5 Oct. | Wigwam | 6 | 2 | 1.12 | 1.12 | 11.0 ^a /5.0 ^b |
| 4 Oct. | Wigwam | 7 | 3 | 0 | 0 | 11.8 ^a /7.0 ^b |
| 4 Oct. | Wigwam | 9 | 4 | 0.49 | 0.49 | 12.4 ^a /5.0 ^b |
| 14 Sept. | Bighorn | 1 | 1 | 0.57 | 0.57 | 7.0 ^a /7.0 ^b |

^a – Spot water temperature during electrofishing (August 9 – 14; Prince and Cope 2001).

^b – Spot water temperature during habitat survey (Sept 19 – Oct. 4; Prince and Cope 2001).

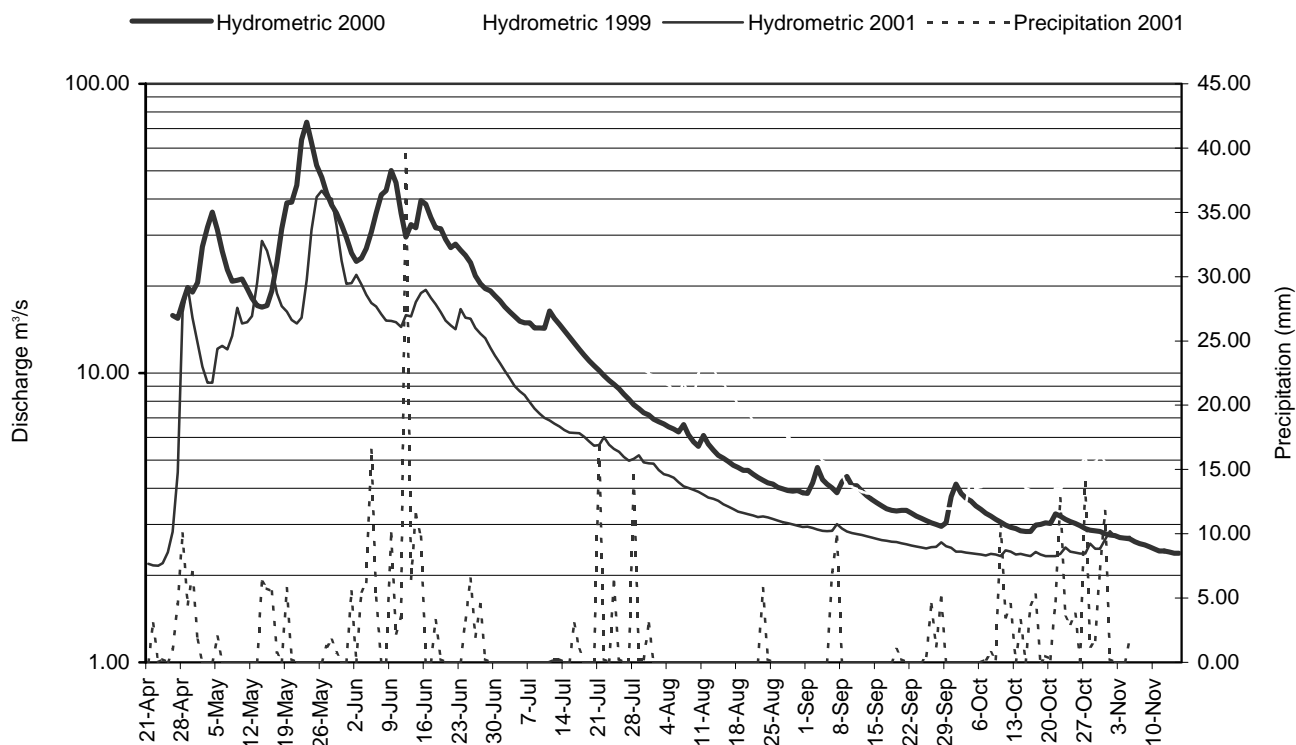


Figure 6. Mean daily discharge and total precipitation for the Wigwam River in 1999, 2000, and 2001 (Prince and Morris 2001).

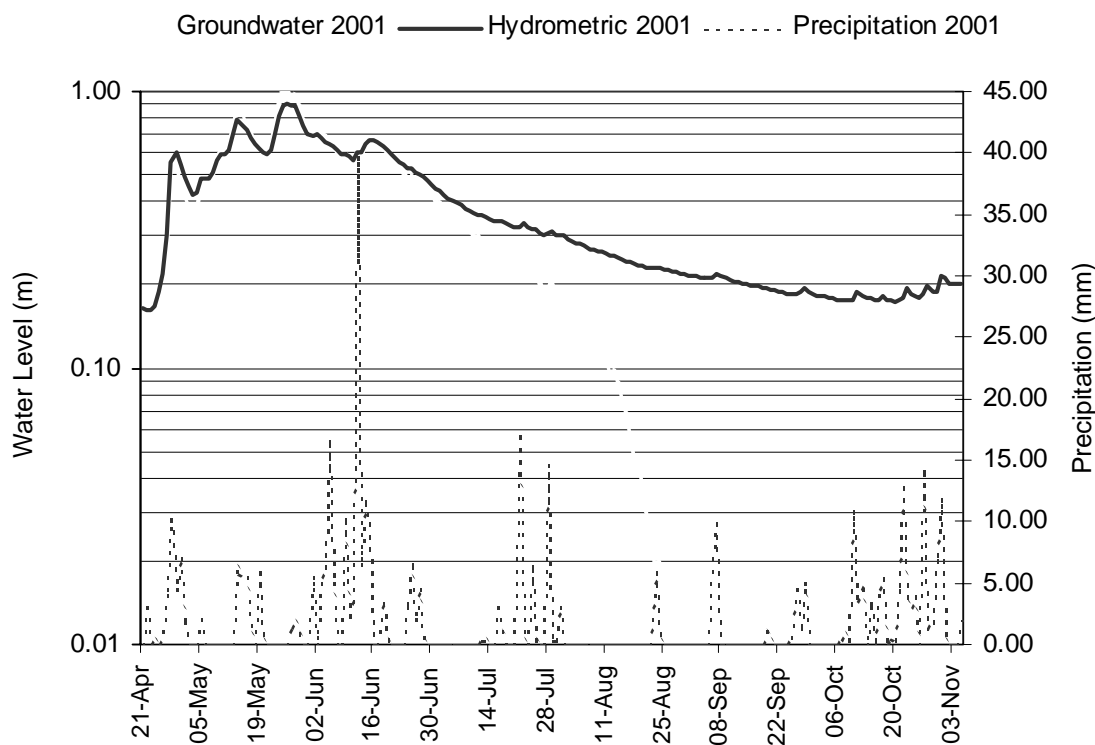


Figure 7. Mean daily water levels recorded at the hydrometric (Wigwam River bridge @ km 45) station and groundwater station (Reach 7, EMS No. 238246), 2000 (Prince and Morris 2002).

Spot temperatures during the first year of sampling (2000) were well within bull trout tolerance limits ($<18^{\circ}\text{C}$) and in general, were indicative of cold perennial springs preferred by bull trout ($<12^{\circ}\text{C}$). Peak mean weekly maximum water temperatures for the Wigwam River at the hydrometric station occurred during the week of 05-11 August and reached 13°C . Water temperatures did not exceed the provincial guideline of 15°C for streams with bull trout, within the provincial guidelines for bull trout rearing (Prince and Morris 2002). Mean daily, and mean weekly maximum water temperatures for the Wigwam River at the hydrometric and groundwater stations (2001) are summarized in Figures 8 and 9. As in previous years, water temperatures at the hydrometric station were significantly correlated with air temperatures and air temperatures did not significantly differ among years (Prince and Morris 2002).

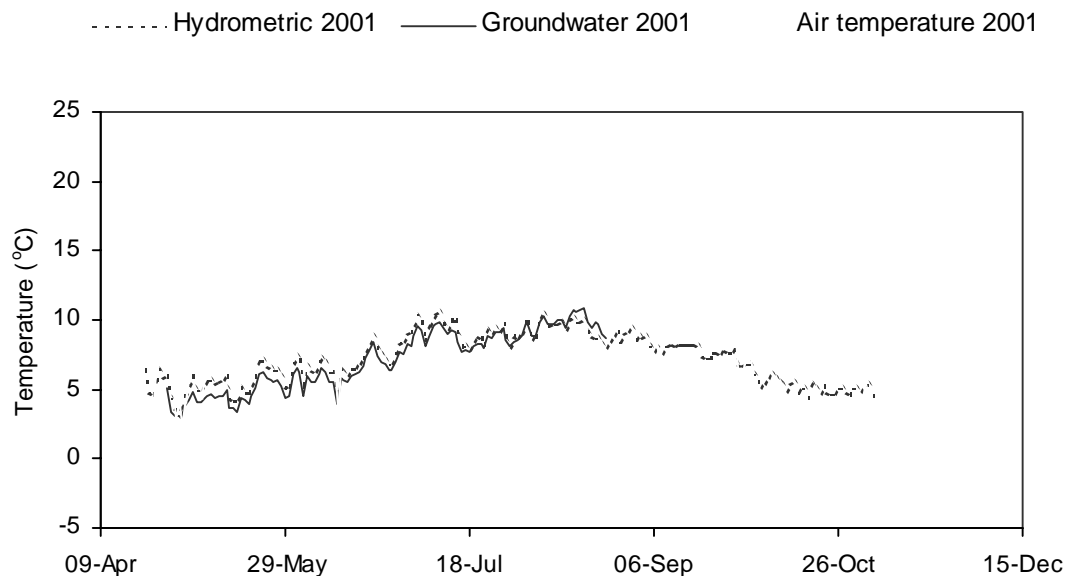


Figure 8. Daily maximum water temperatures recorded at the hydrometric station (Reach 5, EMS No. E238242) and the groundwater station (Reach 7, EMS No. 238246), 2000 (Prince and Cope 2001).

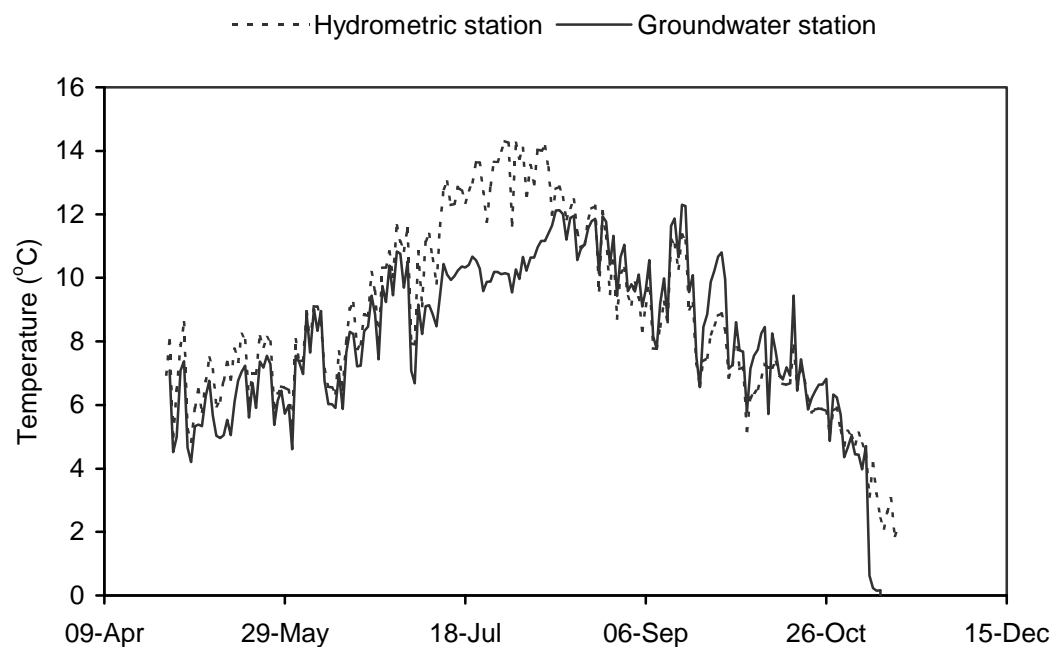


Figure 9. Mean daily water temperatures for the Wigwam River hydrometric and groundwater stations, 2001 (Prince and Morris 2002).

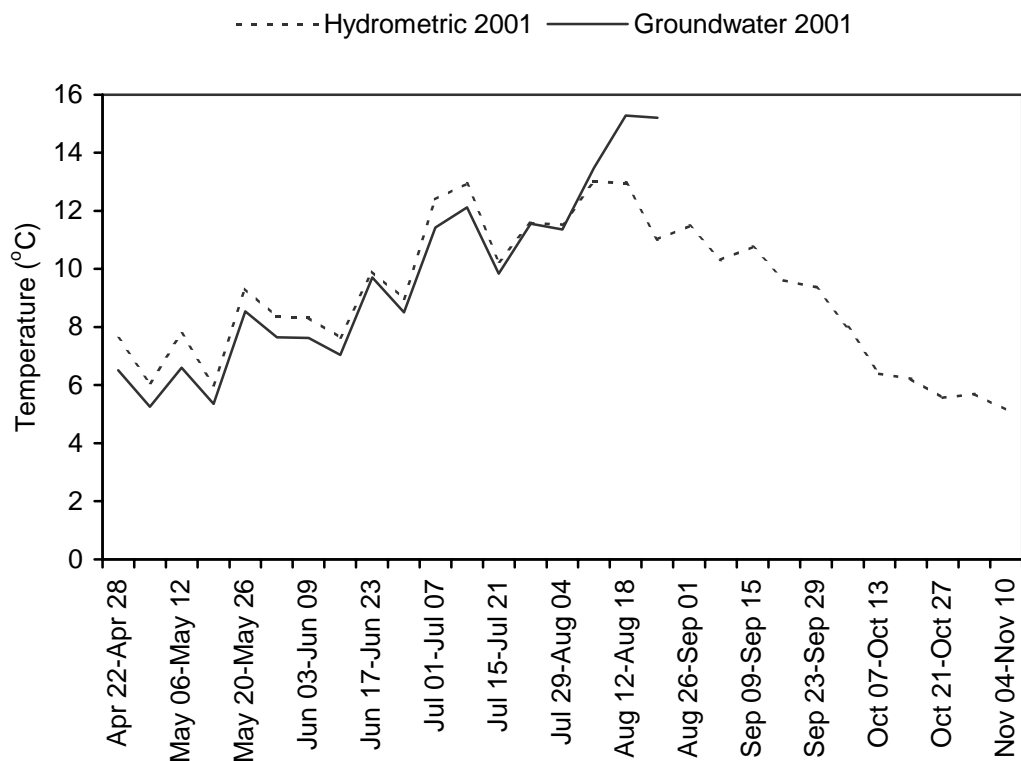


Figure 10. Mean weekly maximum water temperatures for the Wigwam River recorded at the hydrometric and groundwater stations, 2001 (Prince and Morris 2002).

3.1.2 Substrate Pebble Counts

The preferred spawning reaches (Wigwam River reach five, six and reach one of Bighorn) were dominated by small cobble and large gravel substrate ranging in particle size from 32 mm to 96 mm (Table 3.7) and did not vary significantly from the previous year. Reach seven was dominated by large cobble and reach nine was dominated by small boulder. With a low flood peak and lower than average snow pack, larger (i.e. bankfull or channel forming) flows were not present and likely resulted in less channel movement. There were slightly higher levels of fines observed compared with those documented in the previous year (Prince and Morris 2002).

Table 7 Summary of substrate pebble counts (mode, D50, D90) for the Wigwam River fish habitat monitoring sites.

| Stream | Reach | Site | Mode (Particle Class mm) | D ₅₀ (Particle class mm) | D ₉₀ (Particle class mm) |
|---------|-------|------|-----------------------------|--|--|
| Wigwam | 5 | 1 | 64 – 96 | 64 – 96 | 192 – 256 |
| Wigwam | 6 | 2 | 48 – 64 | 32 - 48 | 96 - 128 |
| Wigwam | 7 | 3 | 128 – 192 | 64 – 96 | 192 – 256 |
| Wigwam | 9 | 4 | 256 – 384 | 128 - 192 | 512 – 1024 |
| Bighorn | 1 | 1 | 32 – 48 | 24 - 32 | 64 - 96 |

3.1.3 Channel Surveys

Channel longitudinal and cross sectional profiles were again completed for each of the sample stations. While the channel cross sections and longitudinal sections changed slightly (as expected), the degree of change was minimal. Lower than average flows for the period from April to November would suggest that the effect of the freshet on channel movement (lateral and down-cutting) was minimal; channel forming flows may not have occurred in the spring and early summer of 2001 (or 2000 for that matter) and this has resulted in stable channel cross and longitudinal sections. The variation between sections may be an artifact of the change from a laser level to the Topcon Level, or from small differences in setup/rod placement.

3.2.3 Fish Habitat Survey (FHAP Form 4)

The Level 1 Fish Habitat Assessment Procedure (FHAP) is a purposive field survey of current habitat conditions for the target species in select reaches. In this study, the Level 1 FHAP Form 4 was completed for the representative sample sites (two meander wavelengths) within the selected reaches. The output of the WRP data reporting tool are presented in Appendix C and have been archived for long-term trend monitoring. Generic diagnostic data have been summarized as descriptors of present habitat condition (Table 3.8). Note that regional criteria for habitat conditions do not exist and current WRP diagnostic criteria to evaluate habitat condition are exclusive of bull trout and Westslope cutthroat trout data.

Notwithstanding these limitations, diagnostic data clearly indicate the high quality spawning and rearing habitat ratings for reach six of the Wigwam River and reach one of Bighorn Creek. These reaches demonstrate the importance of LWD and its relationship to habitat diversity and substrate storage and diversity. Reach five pool habitat features were under-represented by site-selection bias for juvenile bull trout and the limitation of two meander wavelengths (400 m) to accurately represent 10.4 km of stream channel. Reaches seven and nine of the Wigwam River were accurately represented as more confined, higher energy reaches with lower habitat diversity. A brief reach and site summary was provided in the preliminary report for year one of the study (Cope and Morris 2001). Photo-documentation was also recorded on standard MWLAP forms and submitted under separate cover.

Table 8. Diagnostics of salmonid habitat condition at the reach level (from Johnston and Slaney 1996). Note that the individual cell format represents value/rating.

| | Habitat Parameter | | | | | | | | | | | |
|---------------------------|---|--|--|-----------------------------------|--|------------------------|---|--|---|--------------------------------|-------------------------------|----------------------------|
| | Pool % (by area) | Pool Frequency (mean spacing) | LWD Pieces per Bankfull Channel Width | % Wood Cover in Pools | % Boulder Cover in Riffles | % Overhead Cover | Substrate Rearing Habitat (interstitial rating) | Off- Channel Habitat (< 3% gradient) | Holding Pools (> 1 m deep, good cover) | Spawning Gravel Quantity | Spawning Gravel Quality | Redd Scour Potential |
| Reach 5 Wigwam R. | 0 P | 0 P | 13.8 G | N/a | < 10 P | 0 P | Clear G | Some F | None G | Limited G | Suitable G | Low G |
| Reach 6 Wigwam R. | 31.0 F | 1.2 G | 27.5 G | 30 G | < 10 P | < 10 P | Clear G | Extensive G | Adequate G | Extensive G | Suitable G | Low G |
| Reach 7 Wigwam R. | Reach was dry on date of habitat sampling | | | | | | | | | | | |
| Reach 9 Wigwam R. | 0.0 P | 0.0 P | 10.5 G | N/a | 30 G | < 10 P | Clear G | Absent P | Few P | Absent P | Absent P | Extensive P |
| Reach 1 Bighorn Cr. | 32.0 G | 4.8 P | 8.67 G | 5 F | < 10 P | < 10 P | Clear G | Some G | Adequate P | Extensive G | Suitable G | Potential F |

Note: regional standards are not available and diagnostic ratings (G – good, F – fair, P – poor) are generalized ratings from Johnston and Slaney (1996) for streams with a bankfull channel width of less than 15 m.

Note: two representative meander lengths were surveyed, not the entire reach.

4 Discussion

The five permanent sampling sites established in summer 2000 in the Wigwam river drainage (one site on Bighorn Creek and four sites on the mainstem Wigwam River) were again sampled in 2001. The 2001 project year represents the second year of a long-term bull trout monitoring program and current studies focused on collecting baseline information. Forest development within the Canadian portion of the upper Wigwam River commenced in August 1997 (road development) and the first cut-blocks were harvested in the winter of 2000/2001. Approximately 36% of the allowable cut was harvested as of 10 November, 2001 (Volume: 231.5 ha; Prince and Morris 2002).

Relative to co-existing species, bull trout densities usually are low, and most broad faunal surveys indicate less than 5% of the total catch is made up of bull trout (McPhail and Baxter 1996, Reiman and McIntyre 1995). However, in the upper Wigwam River, bull trout represented 92.4% of the catch in 2000, and 95.1% of the catch in 2001. The mean density of all juvenile bull trout was estimated to be 20.7 fish/100m² in 2001 (range 0.9 to 24.0 fish/100m²) as compared to 17.2 fish/100m² (range 0 to 26.9 fish/100m²) in 2000. The increase resulted from an increase in Bighorn Creek fry densities. Wigwam River mainstem sites remained remarkably consistent. It was interesting to note that last winter Reach 7, Site 3 dewatered yet fry density was 18.6 fish/100m². This year this site dewatered 92 days earlier. Fry again dominated the catch and this was a direct result of juvenile bull trout ecology and habitat partitioning among life history stages. Site selection was biased towards electrofishing sample sites which favored high bull trout fry capture success.

Areas with juvenile bull trout densities greater than 1.5 fish/100m² have been cited as critical rearing areas (Goetz 1989), and previously reported juvenile densities within the upper Wigwam River are some of the highest recorded (Cope 1998). Comparison of fry density estimates replicated across both the preliminary survey (Cope 1998) and years 1 and 2 of the current study illustrate the stable nature of these high densities (Table 4.1). To eliminate spatial and sampler bias, the identical habitat units were sampled within reaches five and seven using the same personnel and methods.

Table 9. Comparative bull trout fry density estimates for 1997, 2000, and 2001 surveys.

| | Density Estimate (mean +/- 95% confidence Interval) | | |
|---------|---|--------------------|--------------------|
| | 1997 | 2000 | 2001 |
| Reach 5 | 15.6 (13.5 – 18.6) | 17.1 (14.7 – 19.8) | 16.7 (14.6 – 19.3) |
| Reach 7 | 16.8 (14.8 – 18.9) | 16.4 (16.0 – 17.3) | 18.6 (15.3 – 23.1) |

When compared to other bull trout systems, the large spawning escapement (Baxter and Westover 2000) and high juvenile densities provide a strong case that the Wigwam River may be the most prolific bull trout population in the species distributional range. At the very least, it can be concluded that the pre-forest harvesting population of upper Wigwam River bull trout represent a large and stable population with high juvenile bull trout densities. Bull trout populations have been shown to be extremely susceptible to habitat degradation and over harvest (McPhail and Baxter 1996, Ratliff et al. 1996) and are ecologically important as an indicator of watershed health (Baxter 1997). As such, the upper Wigwam River watershed remains relatively pristine, and maintains high water quality (Prince and Cope 2001), high habitat capability (Oliver and Cope 1999) and, conservative angling regulations have been successful in preventing over-exploitation (Baxter and Westover 2000).

While discharge followed a similar pattern between years, mean monthly discharge in 2001 was significantly lower from April to November 2000 than during the same period in 2000. Conversely there was a 26% increase in precipitation from April to November 2001 over the same period in 2000. Snowpack is not currently monitored in the Wigwam River, but regionally, 2001 was said to have only 50-53% of normal levels (Environment Canada 2001). It appears that annual snow pack and groundwater recharge largely determine the hydrograph of the Wigwam River (Prince and Morris 2002). While Reach 7 dewatered earlier than noted in previous years, the effects appear to have been masked by increased escapement and slightly higher fry densities. It will be important to compare fry densities and overall recruitment with bull trout redd numbers over the study period as the study progresses, to determine what role (if any) the dewatering plays in redd density and juvenile production. The annual dewatering and associated high recruitment/fry numbers may emphasize the importance of groundwater and/or subsurface (interflows) in providing important fry/juvenile habitat for bull trout populations.

Maximum summer water temperatures of 14 – 18°C appear to limit bull trout distribution (Baxter and McPhail 1996). Furthermore, the inverted temperature profile across seasons between upper and lower temperature monitoring locations further demonstrates the influence of groundwater and/or sub-surface streambed flow in maintaining preferred bull trout spawning and incubation temperatures within the upper Wigwam River valley (Prince and Cope 2001). Any increase in water temperature and/or decrease in groundwater could result in limitations to juvenile bull trout distribution.

Trends in abundance appeared to be related to proximity to spawning areas, bed material size, water depth and LWD. The association of bull trout fry with shallow (5 – 20 cm), low velocity (<0.3 m/s), cobble dominated stream margin habitat has been previously documented within the Wigwam River (Cope 1998). The upper Wigwam River is comprised of sorted gravels and small cobbles with a very low percentage of fines that provide prime spawning and rearing habitat. Extensive groundwater and sub-surface streambed exfiltration maintains water temperatures and base winter flows.

The range of morphological stream types (B2, C3, C4, D4) encompass the depositional (aggrading) to degrading and sensitive to resilient spectrum and vary from very low to very high bedload sediment yields. A number of site-specific disturbance features of note included sediment wedges, extensive unvegetated bars and lateral instability. Aerial photographs (35 mm) within reach six dating to the late 1970's demonstrate remarkable similarity to recent photographs (Cope and Morris 2001). Although reach six appears to be aggrading these photographs suggest stability. This was in spite of the 1995 rain-on-snow event generally believed to represent a 1 in 150 year flood event. Minor shifting of braids and some down-cutting has occurred since 1995 but no major change in geo-morphology or bed material size class has occurred since the late 1970's. While the reach may appear unstable at first glance, the above observations suggest the D4 stream channel (usually unstable and aggrading), although a very high sediment storage and bedload yield reach, is currently in equilibrium and relatively stable. This reach contains some of the prime bull trout spawning grounds found in the Wigwam River and should be considered very sensitive. The diagnostics summary table (Table 8) demonstrates the importance of LWD to stream structure and sediment storage, habitat diversity, and stability within this reach.

5 References

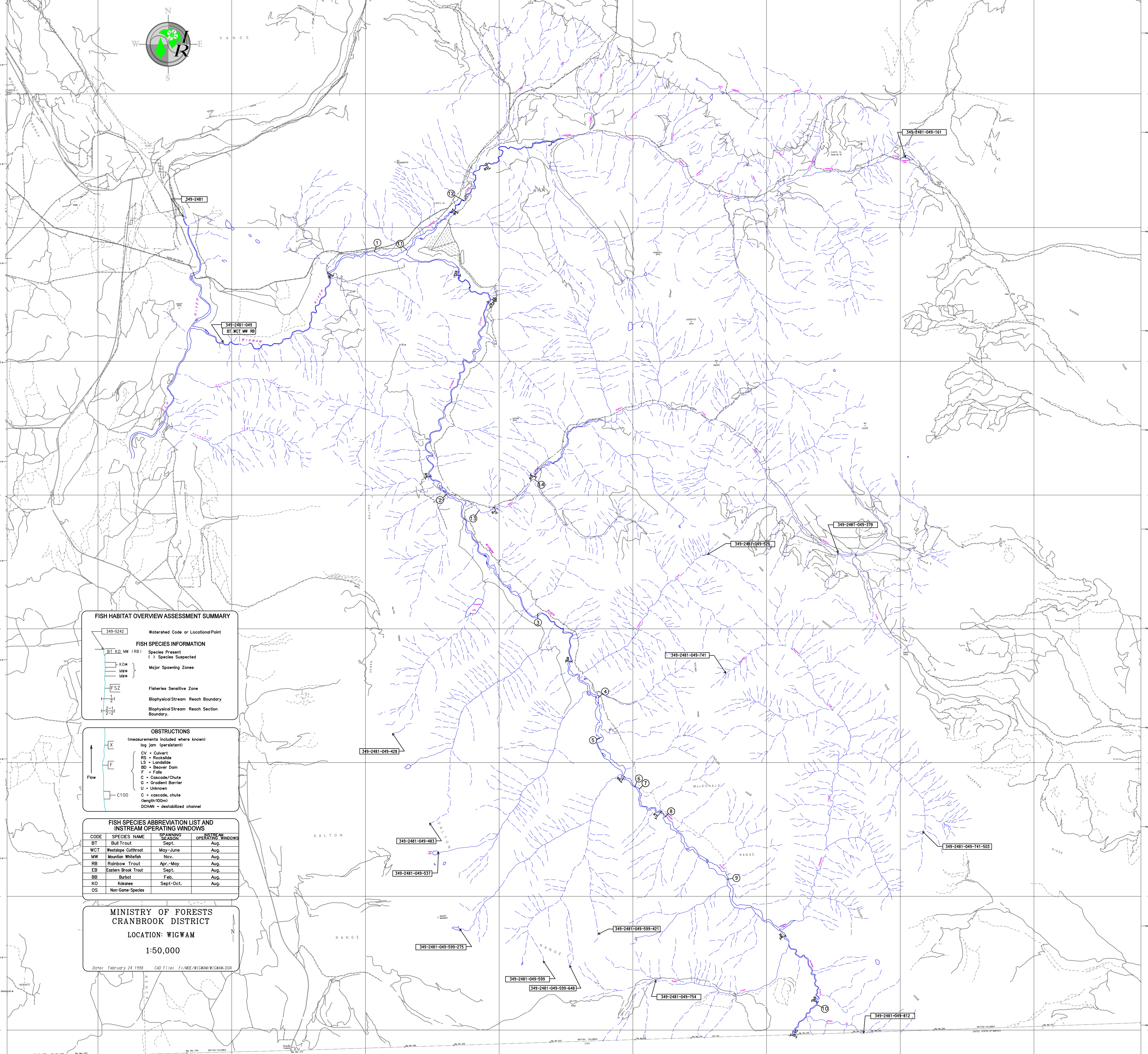
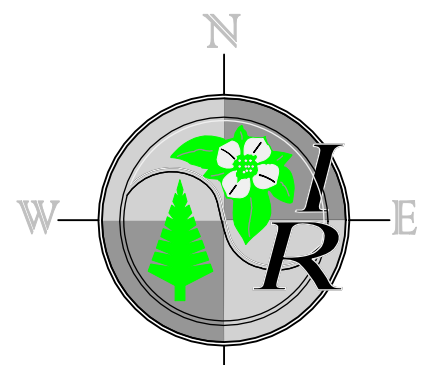
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Appendix A

1:50,000 TRIM Map



FISH HABITAT OVERVIEW ASSESSMENT SUMMARY

349-5242 Watershed Code or Locational Point

FISH SPECIES INFORMATION

BT KO MW (RB) Species Present
() Species Suspected

Major Spawning Zones

FSZ Fisheries Sensitive Zone

Biophysical Stream Reach Boundary

Biophysical Stream Reach Section Boundary

OBSTRUCTIONS
(measurements included where known)
log jam (persistent)

Flow

CV - Culvert
RS - Rockslide
LS - Landslide
BD - Beaver Dam
F - Falls
C - Cascade/Chute
G - Gradient Barrier
U - Unknown
C - cascade, chute (length=100m)
DOHAN - destabilized channel

| FISH SPECIES ABBREVIATION LIST AND INSTREAM OPERATING WINDOWS | | | |
|---|---------------------|-----------------|----------------------------|
| CODE | SPECIES NAME | SPAWNING SEASON | INSTREAM OPERATING WINDOWS |
| BT | Bull Trout | Sept. | Aug. |
| WCT | Westslope Cutthroat | May-June | Aug. |
| MW | Mountain Whitefish | Nov. | Aug. |
| RB | Rainbow Trout | Apr.-May | Aug. |
| EB | Eastern Brook Trout | Sept. | Aug. |
| BB | Burbot | Feb. | Aug. |
| KO | Kokanee | Sept-Oct. | Aug. |
| OS | Non-Game Species | | |

**MINISTRY OF FORESTS
CRANBROOK DISTRICT**

LOCATION: WIGWAM

1:50,000

Date: February 24 1998 CAD File: F:\MOE\WIGWAM\WIGWAM.DGN

Appendix B

Fish Capture Data

Table B1. Summary of electroshocking sample effort and catch in the Wigwam River and Bighorn Creek, 3 to 9 August 2001.

| Reach No. | Site No. | Haul No. | Sample Effort | | Catch (number of fish) | | | | Total Catch |
|----------------|----------|----------|---------------|---------------------|----------------------------------|-----------------------------------|-----------------------------------|------------------------------------|-------------|
| | | | Time (s) | Area m ² | BT ¹ fry ³ | WCT ² fry ³ | BT ¹ juv. ⁴ | WCT ² juv. ⁴ | |
| 1 ^a | 1 | 1 | 1395 | 240 | 58 | | | 1 | 59 |
| 1 ^a | 1 | 2 | 1284 | 240 | 23 | | | | 23 |
| 1 ^a | 1 | 3 | 1004 | 240 | 19 | | | | 19 |
| 1 ^a | 2 | 1 | 1172 | 215.6 | 17 | | | | 17 |
| 1 ^a | 2 | 2 | 1004 | 215.6 | 11 | | | | 11 |
| 1 ^a | 2 | 3 | 270 | 215.6 | 2 | | | | 2 |
| SUBTOTAL | | 1 | 2567 | 455.6 | 75 | 0 | 0 | 1 | 76 |
| | | 2 | 2288 | 455.6 | 34 | 0 | 0 | 0 | 34 |
| | | 3 | 1274 | 455.6 | 21 | 0 | 0 | 0 | 21 |
| TOTAL | | | 6129 | 455.6 | 130 | 0 | 0 | 1 | 131 |
| 5 | 1 | 1 | 1182 | 150 | 11 | 1 | | | 12 |
| 5 | 1 | 2 | 798 | 150 | 10 | 3 | | | 13 |
| 5 | 1 | 3 | 920 | 150 | 3 | 2 | | | 5 |
| 5 | 2 | 1 | 1154 | 208.8 | 21 | 2 | | | 23 |
| 5 | 2 | 2 | 1038 | 208.8 | 14 | 1 | | | 15 |
| 5 | 2 | 3 | 969 | 208.8 | 7 | 2 | | | 9 |
| 5 | 3 | 1 | 1169 | 180 | 10 | 3 | | 1 | 14 |
| 5 | 3 | 2 | 571 | 180 | 3 | 0 | | 3 | 6 |
| 5 | 3 | 3 | 0 | 180 | | | | | 0 |
| SUBTOTAL | | 1 | 3505 | 538.8 | 42 | 6 | 0 | 1 | 49 |
| | | 2 | 2407 | 538.8 | 27 | 4 | 0 | 3 | 34 |
| | | 3 | 1889 | 538.8 | 10 | 4 | 0 | 0 | 14 |
| TOTAL | | | 7801 | 538.8 | 79 | 14 | 0 | 4 | 97 |
| 6 | 1 | 1 | 1147 | 195 | 32 | | | | 32 |
| 6 | 1 | 2 | 881 | 195 | 9 | | | | 9 |
| 6 | 1 | 3 | 984 | 195 | 10 | | | | 10 |
| 6 | 2 | 1 | 1036 | 170 | 8 | | | | 8 |
| 6 | 2 | 2 | 940 | 170 | 7 | | | | 7 |
| 6 | 2 | 3 | 807 | 170 | 1 | | | | 1 |
| 6 | 3 | 1 | 1317 | 176 | 25 | | | | 25 |
| 6 | 3 | 2 | 1126 | 176 | 19 | | 1 | | 20 |
| 6 | 3 | 3 | 857 | 176 | 8 | | | | 8 |
| SUBTOTAL | | 1 | 3500 | 541 | 65 | 0 | 0 | 0 | 65 |
| | | 2 | 2947 | 541 | 35 | 0 | 1 | 0 | 36 |
| | | 3 | 2648 | 541 | 19 | 0 | 0 | 0 | 19 |
| TOTAL | | | 9095 | 541 | 119 | 0 | 1 | 0 | 120 |

^a Bighorn Creek

¹ Bull Trout

² Westslope Cutthroat Trout

³ 0+ age group

⁴ 1+, 2+, 3+ age groups combined

Cont...

Table B1. Contd.

| Reach No. | Site No. | Haul No. | Sample Effort | | Catch (number of fish) | | | | Total Catch |
|-------------|----------|----------|---------------|---------|----------------------------------|-----------------------------------|-----------------------------------|------------------------------------|-------------|
| | | | Time (s) | Area m2 | BT ¹ fry ³ | WCT ² fry ³ | BT ¹ juv. ⁴ | WCT ² juv. ⁴ | |
| 7 | 1 | 1 | 1503 | 208.25 | 18 | | 3 | | 21 |
| 7 | 1 | 2 | 1052 | 208.25 | 7 | | | | 7 |
| 7 | 1 | 3 | 760 | 208.25 | 6 | | | | 6 |
| 7 | 2 | 1 | 1134 | 137.8 | 14 | | 3 | | 17 |
| 7 | 2 | 2 | 849 | 137.8 | 6 | | 3 | | 9 |
| 7 | 2 | 3 | 962 | 137.8 | 6 | | 1 | | 7 |
| 7 | 3 | 1 | 731 | 105 | 5 | | | | 5 |
| 7 | 3 | 2 | 775 | 105 | 5 | | | | 5 |
| 7 | 3 | 3 | 770 | 105 | 2 | 1 | | | 3 |
| SUBTOTAL | | 1 | 3368 | 451.05 | 37 | 0 | 6 | 0 | 43 |
| | | 2 | 2676 | 451.05 | 18 | 0 | 3 | 0 | 21 |
| | | 3 | 2492 | 451.05 | 14 | 1 | 1 | 0 | 16 |
| TOTAL | | | 8536 | 451.05 | 69 | 1 | 10 | 0 | 80 |
| 9 | 1 | 1 | 1029 | 255 | 4 | | 5 | | 9 |
| 9 | 1 | 2 | 849 | 255 | 6 | | 3 | | 9 |
| 9 | 1 | 3 | 806 | 255 | 6 | | 1 | | 7 |
| 9 | 2 | 1 | 686 | 140 | 7 | 1 | 1 | | 9 |
| 9 | 2 | 2 | 747 | 140 | 4 | 1 | 2 | | 7 |
| 9 | 2 | 3 | 566 | 140 | 0 | | | | 0 |
| 9 | 3 | 1 | 816 | 121 | 4 | | | | 4 |
| 9 | 3 | 2 | 762 | 121 | 0 | | | | 0 |
| 9 | 3 | 3 | 0 | 121 | | | | | 0 |
| SUBTOTAL | | 1 | 2531 | 516 | 15 | 1 | 6 | 0 | 22 |
| | | 2 | 2358 | 516 | 10 | 1 | 5 | 0 | 16 |
| | | 3 | 1372 | 516 | 3 | 0 | 0 | 1 | 4 |
| TOTAL | | | 4889 | 516 | 28 | 2 | 11 | 1 | 42 |
| GRAND TOTAL | | | 36450 | 2502.45 | 425 | 17 | 22 | 6 | 470 |

^a Bighorn Creek¹ Bull Trout² Westslope Cutthroat Trout³ 0+ age group⁴ 1+, 2+, 3+ age groups combined

Table B2. Summary of site population estimates and density estimates for bull trout (BT) within the Wigwam River study area, 3 to 9 August, 2001. Note that three pass removal-depletion method was used to estimate abundance (see catch summary).

| Life Stage | Site Estimate | | | | | | |
|--|--------------------------------------|--|---|--|---|--|---------------------|
| | Population Estimate (No. of Fish) | Low 95% Confidence Interval (No. of Fish) | High 95% Confidence Interval (No. of Fish) | Density Estimate (No./100m ²) | Low 95% Confidence Interval (No./100m ²) | High 95% Confidence Interval (No./100m ²) | Capture Probability |
| Wigwam River, Reach 5, Site 1 (538.8 m ²) | | | | | | | |
| BT Fry | 90 | 79 | 104.087 | 16.70378619 | 14.66221232 | 19.31829993 | 0.497 |
| BT Juv. | | | | | | | |
| Wigwam River, Reach 6, Site 2 (541.0 m ²) | | | | | | | |
| BT Fry | 139 | 119 | 159.135 | 25.69316081 | 21.99630314 | 29.41497227 | 0.472 |
| BT Juv. | | | | | | | |
| Wigwam River, Reach 7, Site 3 (451.05 m ²) | | | | | | | |
| BT Fry | 84 | 69 | 104.021 | 18.6232125 | 15.29763884 | 23.06196652 | 0.431 |
| BT Juv. | 10 | 10 | 11.944 | 2.217049108 | 2.217049108 | 2.648043454 | 0.667 |
| Wigwam River, Reach 9, Site 4 (516.0 m ²) | | | | | | | |
| BT Fry | 30 | 28 | 35.802 | 5.813953488 | 5.426356589 | 6.938372093 | 0.56 |
| BT Juv. | 11 | 11 | 12.755 | 2.131782946 | 2.131782946 | 2.471899225 | 0.688 |
| Bighorn Creek, Reach 1, Site 1 (455.6 m ²) | | | | | | | |
| BT Fry | 148 | 130.324 | 165.676 | 32.48463565 | 28.60491659 | 36.3643547 | 0.500 |
| BT Juv. | | | | | | | |
| Mean Densities | | | | | | | |
| BT Fry | | | | 19.9 | 17.2 | 23.0 | |
| BT Juv. | | | | 0.9 | 0.9 | 1.0 | |
| Combined | | | | 20.7 | 18.1 | 24.0 | |

Table B3. Summary of site population estimates and density estimates for Westslope cutthroat trout (WCT) within the Wigwam River study area, 3 to 9 August, 2001. Note that three pass removal-depletion method was used to estimate abundance (see catch summary).

| Life Stage | Site Estimate | | | | | | |
|--|--------------------------------------|--|---|--|---|--|---------------------|
| | Population Estimate (No. of Fish) | Low 95% Confidence Interval (No. of Fish) | High 95% Confidence Interval (No. of Fish) | Density Estimate (No./100m ²) | Low 95% Confidence Interval (No./100m ²) | High 95% Confidence Interval (No./100m ²) | Capture Probability |
| Wigwam River, Reach 5, Site 1 (538.8 m ²) | | | | | | | |
| WCT Fry | 0 | | | | | | |
| WCT Juv. | 1 | | | | | | |
| Wigwam River, Reach 6, Site 2 (541.0 m ²) | | | | | | | |
| WCT Fry | 0 | | | | | | |
| WCT Juv. | 0 | | | | | | |
| Wigwam River, Reach 7, Site 3 (451.05 m ²) | | | | | | | |
| WCT Fry | 1 | | | | | | |
| WCT Juv. | 0 | | | | | | |
| Wigwam River, Reach 9, Site 4 (516.0 m ²) | | | | | | | |
| WCT Fry | 20 | 14 | 41.011 | 3.875968992 | 2.713178295 | 7.947868217 | 0 |
| WCT Juv. | 0 | | | | | | |
| Bighorn Creek, Reach 1, Site 1 (455.6 m ²) | | | | | | | |
| WCT Fry | 0 | | | | | | |
| WCT Juv. | 1 | | | | | | |
| Mean Densities | | | | | | | |
| WCT Fry | | | | 0.8 | 0.5 | 1.6 | |
| WCT Juv. | | | | 0.0 | 0.0 | 0.0 | |
| Combined | | | | 0.8 | 0.5 | 1.6 | |

Appendix C

FHAP Level 1 Form 4 Data

Level 1 - Habitat Summary Diagnosis Report

| | | | |
|--------------------------------------|--|--|--|
| Form Number: 881 | | Forest District: CRANBROOK | |
| | | Watershed Name: WIGWAM RIVER | |
| | | Watershed Code: 349-248100-04900-00000-00000-0000-000-000-000-000-000 | |
| Survey Date: 9/14/01 | | Weather: CLEAR | |
| | | Survey Crew: SC/KM | |
| Discharge: (cubic meters per second) | | | |
| Subsampling Fractions: | | | |
| Riffles 1 in 1 | | Pools 1 in 1 | |
| Glides 1 in 1 | | Cascades | |
| | | Other | |

| Detail No | Sub Basin Name | Reach No | Section No | UTM | | | Distance (m) | Habitat Unit | | Length (m) | Grad (%) | Mean Depth | | Mean Width | | Pools Only | | | |
|------------|----------------|--|------------|------|---------|----------|--------------|--------------|-----|------------|----------|--------------|-----------|--------------|------------|---------------|-----------|--------------|-----------|
| | | | | Zone | Easting | Northing | | Type | Cat | | | Bankfull (m) | Water (m) | Bankfull (m) | Wetted (m) | Max Depth (m) | Crest (m) | Residual (m) | Pool Type |
| 1 | BIGHORN CR. | 1 | 1 | 11 | 648335 | 5449685 | 743 | R | 1 | 11 | 0.5 | 1 | 0.32 | 32.6 | 6 | | | | |
| Comments : | | LITTLE MORE WOOD, MORE FINES ALSO, AND GRAVEL DEPOSITED | | | | | | | | | | | | | | | | | |
| 2 | BIGHORN CR. | 1 | 1 | 11 | 649158 | 6449604 | 732 | G | 1 | 36 | 0.5 | 1.2 | 0.55 | 15.6 | 5.6 | | | | |
| Comments : | | MUCH MORE FINES AND SAND DEPOSITED | | | | | | | | | | | | | | | | | |
| 3 | BIGHORN CR. | 1 | 1 | 11 | 545234 | 5505567 | 36 | P | 1 | 10 | 0.5 | 0.9 | 0.42 | 33.5 | 4.8 | 0.55 | 0.28 | 0.27 | S |
| Comments : | | 1 REDD STARTING | | | | | | | | | | | | | | | | | |
| 4 | BIGHORN CR. | 1 | 1 | 11 | 649105 | 5449620 | 636 | P | 1 | 24 | 0.5 | 1.95 | 1 | 28.4 | 9.2 | 1.1 | 0.19 | 0.91 | D |
| Comments : | | LOG JAM GETTING CLOGGED UP WITH SWD - WILL BLOW OUT SOON | | | | | | | | | | | | | | | | | |
| 5 | BIGHORN CR. | 1 | 1 | 11 | 649084 | 5148613 | 612 | R | 1 | 13 | 0.5 | 1.2 | 0.31 | 36.1 | 4.3 | | | | |
| Comments : | | COVER IN ADJACENT (?); BULL TROUT SPAWNING 1 FEMALE, 3 MALES, 1 BIG REDD | | | | | | | | | | | | | | | | | |
| 6 | BIGHORN CR. | 1 | 1 | 11 | 649147 | 5449419 | 599 | P | 1 | 22 | 0.5 | 1.9 | 1 | 35.9 | 10 | 1.1 | 0.18 | 0.92 | S |
| Comments : | | 1 BT REDD | | | | | | | | | | | | | | | | | |
| 7 | BIGHORN CR. | 1 | 1 | 11 | 649064 | 5449590 | 577 | P | 1 | 26 | 0.5 | 1.2 | 0.84 | 14.9 | 7.5 | 0.84 | 0.08 | 0.76 | S |
| Comments : | | | | | | | | | | | | | | | | | | | |
| 8 | BIGHORN CR. | 1 | 1 | 11 | 649089 | 5449439 | 551 | R | 1 | 69 | 0.36 | 0.8 | 0.2 | 36.6 | 4.9 | | | | |
| Comments : | | SAME AS LAST YEAR; COTTONWOOD 1 FOOT HIGHER; STABLE HABITAT | | | | | | | | | | | | | | | | | |
| 9 | BIGHORN CREEK | 1 | 1 | 11 | 649089 | 5449439 | 551 | R | 2 | 69 | 0.36 | 0.6 | 0.13 | 36.6 | 4.9 | | | | |
| Comments : | | FULL OF FRY; VERY STABLE CHANNEL | | | | | | | | | | | | | | | | | |

| NTS Maps (1:50,000) : | | 082G02 | | | | BGGS Maps (1:20,000) : | | | | 082G016 | | | | | | | | | | | | | | | |
|-----------------------|----------|----------|------------|---------|--------|------------------------|----------------|-----------|------|--------------|-----|--------------|----|--------------------|--------|------------|------------------------|----|----|---------------------|-----------|----------------|----------|---|---|
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| Bed Material Type | | | | | | Total LWD Tally | Functional LWD | | | Cover | | | | Offchannel Habitat | | | Disturbance Indicators | | | Riparian Vegetation | | | Barriers | | |
| Dom. | Sub-Dom. | D90 (mm) | Compaction | SG Type | SG Amt | | 10 - 20cm | 20 - 50cm | >50c | Cover Type 1 | % | Cover Type 2 | % | Type | Access | Length (m) | | | | Type | Structure | Canopy Closure | | | |
| G | C | 21 | M | R | H | | 11 | 9 | 2 | | LWD | 5 | C | 5 | SC | G | 300 | 1 | 2 | 3 | M | MF | | 1 | N |
| G | S | 18 | M | R | L | 7 | 4 | 1 | | C | 5 | OV | 5 | | | | | | | M | MF | 1 | N | | |
| C | B | 17 | M | R | H | 13 | 7 | | | LWD | 10 | C | 10 | | | | DW | WG | | M | MF | 1 | N | | |
| G | S | 8 | M | R | L | 24 | 18 | 5 | 1 | LWD | 45 | SWD | 40 | | | | DW | JM | WG | M | MF | 1 | N | | |
| G | C | 30 | M | R | H | 6 | | 1 | | OV | 5 | | | | | | WG | | | M | MF | 1 | N | | |
| G | S | 25 | M | R | L | 6 | 4 | 2 | | DP | 60 | LWD | | SC | G | 300 | EB | WG | | M | MF | 1 | N | | |
| S | G | 16 | M | R | L | 3 | 3 | | | DP | 10 | LWD | 10 | | | | EB | | | | | | | | |
| C | G | 15 | M | R | L | 3 | 3 | | | B | | LWD | | | | | DW | EB | MB | M | MF | 1 | N | | |
| G | C | 15 | M | R | L | 5 | 4 | 1 | | LWD | | | | | | | DW | EB | MB | M | MF | 1 | N | | |

Level 1 - Habitat Summary Diagnosis Report

| | | | |
|--------------------------------------|--|--|--|
| Form Number: 882 | | Forest District: CRANBROOK | |
| | | Watershed Name: WIGWAM RIVER | |
| | | Watershed Code: 349-248100-04900-00000-00000-0000-000-000-000-000-000 | |
| Survey Date: 10/3/01 | | Weather: CLEAR | |
| Discharge: (cubic meters per second) | | Survey Crew: SC/AP | |
| Subsampling Fractions: | | | |
| Riffles 1 in 1 | | Pools 1 in 1 | |
| Glides 1 in 1 | | Cascades 1 in 1 | |
| Other 1 in 1 | | | |

| Detail No | Sub Basin Name | Reach No | Section No | UTM | | | Distance (m) | Habitat Unit | | Length (m) | Grad (%) | Mean Depth | | Mean Width | | Pools Only | | | |
|--|----------------|----------|------------|------|---------|----------|--------------|--------------|-----|------------|----------|--------------|-----------|--------------|------------|---------------|-----------|--------------|-----------|
| | | | | Zone | Easting | Northing | | Type | Cat | | | Bankfull (m) | Water (m) | Bankfull (m) | Wetted (m) | Max Depth (m) | Crest (m) | Residual (m) | Pool Type |
| 1 | WIGWAM RIVER | 5 | 5 | 11 | 648335 | 5449685 | 0 | R | 1 | 100 | | 1.5 | 0.48 | 45.9 | 18.2 | | | | |
| Comments : | | | | | | | | | | | | | | | | | | | |
| 2 | WIGWAM RIVER | 5 | 5 | | | | 100 | G | 1 | 60 | | 1.5 | 0.93 | 33.9 | 18.3 | | | | |
| Comments : | | | | | | | | | | | | | | | | | | | |
| 3 | WIGWAM RIVER | 5 | 5 | 11 | 648156 | 5449614 | 160 | R | 1 | 80 | | 1.5 | 0.46 | | 19.3 | | | | |
| Comments : | | | | | | | | | | | | | | | | | | | |
| 4 | WIGWAM RIVER | 5 | 5 | | | | 240 | G | 1 | 110 | | 1.5 | 0.78 | | 19.8 | | | | |
| Comments : 20 BT REDDS; 1 PAIR LEFT; LWD CUT ON BAR FOR FIREWOOD - GETTING SMALLER | | | | | | | | | | | | | | | | | | | |
| 5 | WIGWAM RIVER | 5 | 5 | | | | 350 | R | 1 | 50 | | 1.5 | 0.48 | 48.2 | 21.1 | | | | |
| Comments : | | | | | | | | | | | | | | | | | | | |

| NTS Maps (1:50,000) : | | 082G03 | | BGGS Maps (1:20,000) : | | 082G016 | | | | | | | | | | | | | | | | | | | |
|-----------------------|----------|----------|------------|------------------------|--------|-----------------|----------------|-----------|------|--------------|----|--------------|----|--------------------|--------|------------|------------------------|----|----|---------------------|-----------|----------------|----------|--|--|
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| Bed Material Type | | | | | | Total LWD Tally | Functional LWD | | | Cover | | | | Offchannel Habitat | | | Disturbance Indicators | | | Riparian Vegetation | | | Barriers | | |
| Dom. | Sub-Dom. | D90 (mm) | Compaction | SG Type | SG Amt | | 10 - 20cm | 20 - 50cm | >50c | Cover Type 1 | % | Cover Type 2 | % | Type | Access | Length (m) | | | | Type | Structure | Canopy Closure | | | |
| | | | | | | | | | | | | | | | | | 1 | 2 | 3 | | | | | | |
| C | B | 345 | M | R | N | 7 | 3 | 2 | | B | 10 | LWD | 2 | SC | P | 100 | DW | FP | DW | M | MF | 1 | N | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| B | C | 350 | M | R | L | 8 | 5 | | | DP | 20 | B | 10 | SC | P | 60 | DW | FP | | C | MF | 1 | N | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| C | B | 250 | | R | N | 18 | 13 | 5 | | B | 10 | LWD | 5 | SC | P | 80 | EB | | | M | MF | 1 | N | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| G | C | 210 | | R | H | 16 | 14 | | | SWD | 5 | C | 5 | SC | P | 150 | DW | FP | | M | MF | 1 | N | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| C | B | 320 | | R | N | 20 | 13 | 3 | | B | 5 | | | SC | G | 120 | DW | FP | PD | M | MF | 1 | N | | |

Level 1 - Habitat Summary Diagnosis Report

| | |
|--------------------------------------|---|
| Form Number: 883 | Forest District: CRANBROOK |
| | Watershed Name: WIGWAM RIVER |
| | Watershed Code: 349-248100-04900-00000-00000-00000-000-000-000-000-000 |
| Survey Date: 10/5/01 | Weather: CLEAR |
| Discharge: (cubic meters per second) | Survey Crew: SC/KM |
| Subsampling Fractions: | |
| Riffles 1 in 1 | Pools 1 in 1 |
| Glides 1 in 1 | Cascades 1 in 1 |
| Other | |

| Detail No | Sub Basin Name | Reach No | Section No | UTM | | | Distance (m) | Habitat Unit | | Length (m) | Grad (%) | Mean Depth | | Mean Width | | Pools Only | | | |
|---|----------------|----------|------------|------|---------|----------|--------------|--------------|-----|------------|----------|--------------|-----------|--------------|------------|---------------|-----------|--------------|-----------|
| | | | | Zone | Easting | Northing | | Type | Cat | | | Bankfull (m) | Water (m) | Bankfull (m) | Wetted (m) | Max Depth (m) | Crest (m) | Residual (m) | Pool Type |
| 1 | WIGWAM RIVER | 6 | 6 | 11 | 653802 | 54418976 | 615 | R | 1 | 55 | | 1 | 0.25 | 68 | 22.7 | | | | |
| Comments : K2:F4 D/S; F5 SPAWNING HAB. EXTENSIVE BAR; | | | | | | | | | | | | | | | | | | | |
| 2 | WIGWAM RIVER | 6 | 6 | 11 | 653770 | 5441871 | 600 | P | 1 | 15 | | 2 | 1.3 | 73.5 | 9.8 | 1.4 | 0.35 | 1.05 | S |
| Comments : NICE POOL; K2: FRAME 3 D/S; BT IN POOL | | | | | | | | | | | | | | | | | | | |
| 3 | WIGWAM RIVER | 6 | 6 | | | | 560 | R | 1 | 40 | | 0.9 | 0.28 | 78.1 | 10.8 | | | | |
| Comments : NEW UNIT; K2:F6 RIF. U/S | | | | | | | | | | | | | | | | | | | |
| 4 | WIGWAM RIVER | 6 | 6 | | | | 520 | G | 1 | 40 | | 1.35 | 0.61 | 88.2 | 11.5 | | | | |
| Comments : 20 BT REDDS; EF SITE; K2:F7 D/S GLIDE/SPAWNING HAB | | | | | | | | | | | | | | | | | | | |
| 5 | WIGWAM RIVER | 6 | 6 | 11 | 653835 | 5441798 | 460 | R | 1 | 50 | | 1.1 | 0.9 | 88 | 11.2 | 0.9 | 0.3 | 0.6 | S |
| Comments : APPROX. 5 BT IN POOL; K2:F8 X/C POOL | | | | | | | | | | | | | | | | | | | |
| 6 | WIGWAM RIVER | 6 | 6 | 11 | 653835 | 5441798 | 460 | R | 1 | 50 | | 1.1 | 0.4 | 85 | 14 | | | | |
| Comments : 3 BT REDDS | | | | | | | | | | | | | | | | | | | |
| 7 | IGWAM RIVE | 6 | 6 | | | | 410 | P | 1 | 40 | | 2.6 | 1.7 | 76.8 | 14 | 1.7 | 0.3 | 1.4 | S |
| Comments : 7 BT REDDS; NICE POOL FOR BT & WCT; LWD SUBMERGED IN POOL; K2:F9 X/C POOL | | | | | | | | | | | | | | | | | | | |
| 8 | WIGWAM RIVER | 6 | 6 | | | | 300 | R | 1 | 120 | | 1.25 | 0.4 | 55 | 9.7 | | | | |
| Comments : LOTS OF LWD; 3 BT NEAR LWD; K2:F10 D/SA LONG RIFFLE | | | | | | | | | | | | | | | | | | | |
| 9 | WIGWAM RIVER | 6 | 6 | | | | 230 | P | 1 | 70 | | 2.1 | 1.1 | 130 | 15 | 1.5 | 0.4 | 1.1 | S |
| Comments : APPROX. 10 BT REDDS; SC BLOCKED BY BD; K2:F11 X/S LWD P00 | | | | | | | | | | | | | | | | | | | |
| 10 | WIGWAM RIVER | 6 | 6 | | | | 160 | R | 1 | 70 | | 1.3 | 0.4 | 150 | 11 | | | | |
| Comments : SC IS HENRY' STRIB; BT SPAWNING; K2:F12 X/C LUB-RUB | | | | | | | | | | | | | | | | | | | |
| 11 | WIGWAM RIVER | 6 | 6 | | | | 70 | G | 1 | 90 | | 1.3 | 0.45 | 130 | 15 | | | | |
| Comments : 10 BT REDDS ALL ALONG LUB; UNDER OV/CB | | | | | | | | | | | | | | | | | | | |
| 12 | WIGWAM RIVER | 6 | 6 | 11 | 653886 | 5441349 | 0 | P | 1 | 70 | | 2.5 | 1.5 | | | 1.9 | 0.3 | 1.6 | S |
| Comments : 2 BT REDDS; 7 BT IN POOL 7 1 WCT | | | | | | | | | | | | | | | | | | | |

| NTS Maps (1:50,000) : | | | | | | 082G03 | | BGS Maps (1:20,000) : | | | | | | 082G006 | | | | | | | | | | | |
|-----------------------|----------|----------|------------|---------|--------|-----------------|----------------|-----------------------|-------|--------------|----|--------------|----|--------------------|--------|------------|------------------------|----|----|---------------------|-----------|----------------|----------|--|--|
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| Bed Material Type | | | | | | Total LWD Tally | Functional LWD | | | Cover | | | | Offchannel Habitat | | | Disturbance Indicators | | | Riparian Vegetation | | | Barriers | | |
| Dom. | Sub-Dom. | D90 (mm) | Compaction | SG Type | SG Amt | | 10 - 20cm | 20 - 50cm | >50cm | Cover Type 1 | % | Cover Type 2 | % | Type | Access | Length (m) | 1 | 2 | 3 | Type | Structure | Canopy Closure | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| G | C | 150 | | R | H | 20 | 9 | 5 | 2 | LWD | 2 | | | SC | G | 55 | DW | MB | MC | M | MF | 1 | N | | |
| G | C | 150 | | R | H | 5 | 2 | 3 | | DP | 60 | LWD | 20 | SC | G | 15 | DW | MB | MC | M | MF | 1 | N | | |
| G | C | 170 | | R | L | 1 | | | | | | | | SC | G | 40 | DW | MB | MC | M | MF | 1 | N | | |
| G | C | 150 | | R | H | 7 | 5 | 2 | | LWD | 2 | DP | 2 | SC | G | 40 | DW | | | M | MF | 1 | N | | |
| G | C | 100 | | R | H | 24 | 21 | 2 | 1 | DP | 10 | LWD | 10 | SC | G | 20 | DW | | | M | MF | 1 | N | | |
| G | C | 120 | | R | H | 10 | 6 | 1 | | LWD | 2 | C | 2 | SC | G | 50 | DW | MC | | M | MF | 1 | N | | |
| G | C | 160 | | R | H | 43 | 31 | 10 | 2 | LWD | 30 | DP | 30 | SC | G | 40 | DW | | | M | MF | 1 | N | | |
| C | G | 180 | | R | L | 53 | 23 | 25 | 5 | LWD | 5 | | | SC | P | 120 | DW | | | M | MF | 1 | N | | |
| G | S | 120 | | R | H | 64 | 27 | 31 | 6 | SWD | 60 | DP | 30 | SC | P | 450 | DW | WG | | M | MF | 1 | N | | |
| C | G | 220 | | R | L | 38 | 24 | 13 | 1 | LWD | 2 | C | 2 | SC | G | 300 | DW | | | M | MF | 1 | N | | |
| G | C | 100 | | R | H | 29 | 14 | 15 | | C | 10 | OV | 5 | | | | DW | | | M | MF | 1 | N | | |
| G | S | 80 | | R | H | 39 | 20 | 16 | 3 | LWD | 15 | DP | 30 | | | | DW | | | M | MF | 1 | N | | |

Level 1 - Habitat Summary Diagnosis Report

| | | | |
|--------------------------------------|--|--|--|
| Form Number: 884 | | Forest District: CRANBROOK | |
| | | Watershed Name: WIGWAM RIVER | |
| | | Watershed Code: 349-248100-04900-00000-00000-0000-000-000-000-000-000 | |
| Survey Date: 10/4/01 | | Weather: CLEAR | |
| Discharge: (cubic meters per second) | | Survey Crew: SC/KM | |
| Subsampling Fractions: | | | |
| Riffles 1 in 1 | | Pools 1 in 1 | |
| Glides 1 in 1 | | Cascades 1 in 1 | |
| Other 1 in 1 | | | |

| Detail No | Sub Basin Name | Reach No | Section No | UTM | | | Distance (m) | Habitat Unit | | Length (m) | Grad (%) | Mean Depth | | Mean Width | | Pools Only | | | |
|------------|----------------|-------------------|------------|------|---------|----------|--------------|--------------|-----|------------|----------|--------------|-----------|--------------|------------|---------------|-----------|--------------|-----------|
| | | | | Zone | Easting | Northing | | Type | Cat | | | Bankfull (m) | Water (m) | Bankfull (m) | Wetted (m) | Max Depth (m) | Crest (m) | Residual (m) | Pool Type |
| 1 | WIGWAM RIVER | 7 | 7 | 11 | 654977 | 5439074 | 0 | R | 1 | 70 | | 1.25 | 0 | 25 | 0 | | | | |
| Comments : | | ROLL#K1 FRAME 23 | | | | | | | | | | | | | | | | | |
| 2 | WIGWAM RIVER | 7 | 7 | | | | 70 | G | 1 | 110 | | 1.25 | 0 | 40 | 0 | | | | |
| Comments : | | ROLL# K1 FRAME 24 | | | | | | | | | | | | | | | | | |
| 3 | WIGWAM RIVER | 7 | 7 | | | | 180 | P | 1 | 20 | | 1.9 | 0 | | 0 | 0.9 | 0 | 0.9 | S |
| Comments : | | ROLL#K2 FRAME 1 | | | | | | | | | | | | | | | | | |
| 4 | WIGWAM RIVER | 7 | 7 | | | | 200 | R | 1 | 30 | | 1.2 | 0 | 40 | 0 | | | | |
| Comments : | | | | | | | | | | | | | | | | | | | |
| 5 | WIGWAM RIVER | 7 | 7 | 11 | 655250 | 5438890 | 230 | P | 1 | 30 | | 1.7 | 0 | 28.6 | 0 | 0.6 | 0 | 0.6 | S |
| Comments : | | ROLL #K2 FRAME 2 | | | | | | | | | | | | | | | | | |
| 6 | WIGWAM RIVER | 7 | 7 | | | | 260 | G | 1 | 40 | | 1.4 | 0 | 26.1 | 0 | | | | |
| Comments : | | | | | | | | | | | | | | | | | | | |
| 7 | WIGWAM RIVER | 7 | 7 | 11 | 655186 | 5438950 | 300 | R | 1 | 270 | | 1 | 0 | 20.9 | 0 | | | | |
| Comments : | | | | | | | | | | | | | | | | | | | |
| 8 | WIGWAM RIVER | 7 | 7 | 11 | 655471 | 5438625 | 570 | G | 1 | 80 | | 1.8 | 0 | 33.1 | 0 | | | | |
| Comments : | | K2 FRAME 3 | | | | | | | | | | | | | | | | | |

| NTS Maps (1:50,000) : | | 082G03 | | BGS Maps (1:20,000) : | | 082G006 | | | | | | | | | | | | | | | | | |
|-----------------------|----------|----------|------------|-----------------------|--------|-----------------|----------------|-----------|-------|--------------|----|--------------|----|--------------------|--------|------------|------------------------|----|----|---------------------|-----------|----------------|----------|
| | | | | | | | | | | | | | | | | | | | | | | | |
| Bed Material Type | | | | | | Total LWD Tally | Functional LWD | | | Cover | | | | Offchannel Habitat | | | Disturbance Indicators | | | Riparian Vegetation | | | Barriers |
| Dom. | Sub-Dom. | D90 (mm) | Compaction | SG Type | SG Amt | | 10 - 20cm | 20 - 50cm | >50cm | Cover Type 1 | % | Cover Type 2 | % | Type | Access | Length (m) | 1 | 2 | 3 | Type | Structure | Canopy Closure | |
| | | | | | | | | | | | | | | | | | | | | | | | |
| C | G | 200 | | R | L | 6 | 5 | 1 | | LWD | 2 | C | 2 | | | | DW | FP | | C | MF | 1 | N |
| G | C | 200 | | R | L | 8 | 3 | 1 | | C | 10 | SWD | 5 | SC | P | 110 | DW | FP | | C | MF | 1 | N |
| C | G | 200 | | R | L | 7 | 6 | 1 | | DP | 20 | LWD | 20 | SC | P | 20 | DW | PD | | C | MF | 1 | N |
| C | G | 300 | | R | L | 0 | | | | B | 2 | | | SC | P | 30 | DW | | | C | MF | 1 | N |
| C | G | 550 | | R | L | 0 | | | | B | 20 | DP | 10 | | | | EB | | | C | MF | 1 | N |
| C | B | 380 | | R | N | 6 | 4 | 2 | | B | 15 | | | | | | EB | | | C | MF | 1 | N |
| C | G | 250 | | R | L | 25 | 16 | 3 | 2 | B | 2 | LWD | 5 | | | | EB | PD | | M | PS | 1 | N |
| C | B | 380 | | R | L | 6 | 6 | | | B | 2 | LWD | 2 | | | | DW | EB | WG | M | PS | 1 | N |

Level 1 - Habitat Summary Diagnosis Report

| | | | |
|--------------------------------------|----------------------------------|--|-----------------------|
| Form Number: 885 | | Forest District: CRANBROOK | |
| | | Watershed Name: WIGWAM RIVER | |
| | | Watershed Code: 349-248100-04900-00000-00000-0000-000-000-000-000-000 | |
| Survey Date: 10/4/01 | Weather: CLOUDY PERIODS, COLD | | Survey Crew: SC/KM |
| Discharge: (cubic meters per second) | | | |
| Subsampling Fractions: | | | |
| Riffles | 1 in 1 | Pools | 1 in 1 |
| Glides | 1 in 1 | Cascades | 1 in 1 |
| Other | 1 in 1 | | |

| Detail No | Sub Basin Name | Reach No | Section No | UTM | | | Distance (m) | Habitat Unit | | Length (m) | Grad (%) | Mean Depth | | Mean Width | | Pools Only | | | |
|------------|----------------|--|------------|------|---------|----------|--------------|--------------|-----|------------|----------|--------------|-----------|--------------|------------|---------------|-----------|--------------|-----------|
| | | | | Zone | Easting | Northing | | Type | Cat | | | Bankfull (m) | Water (m) | Bankfull (m) | Wetted (m) | Max Depth (m) | Crest (m) | Residual (m) | Pool Type |
| | | | | | | | | | | | | | | | | | | | |
| 1 | WIGWAM RIVER | 9 | 9 | 11 | 660830 | 5433065 | 0 | C | 1 | 210 | | 1.1 | 0.42 | 13.8 | 9.6 | | | | |
| Comments : | | TERTAIKY LWD POOL - WILL BLOW OUT; 3NF PIECES OF LWD | | | | | | | | | | | | | | | | | |
| 2 | WIGWAM RIVER | 9 | 9 | 11 | 660942 | 5432911 | 210 | R | 1 | 80 | | 1.12 | 0.4 | 17 | 12.3 | | | | |
| Comments : | | tertiary cascade - | | | | | | | | | | | | | | | | | |

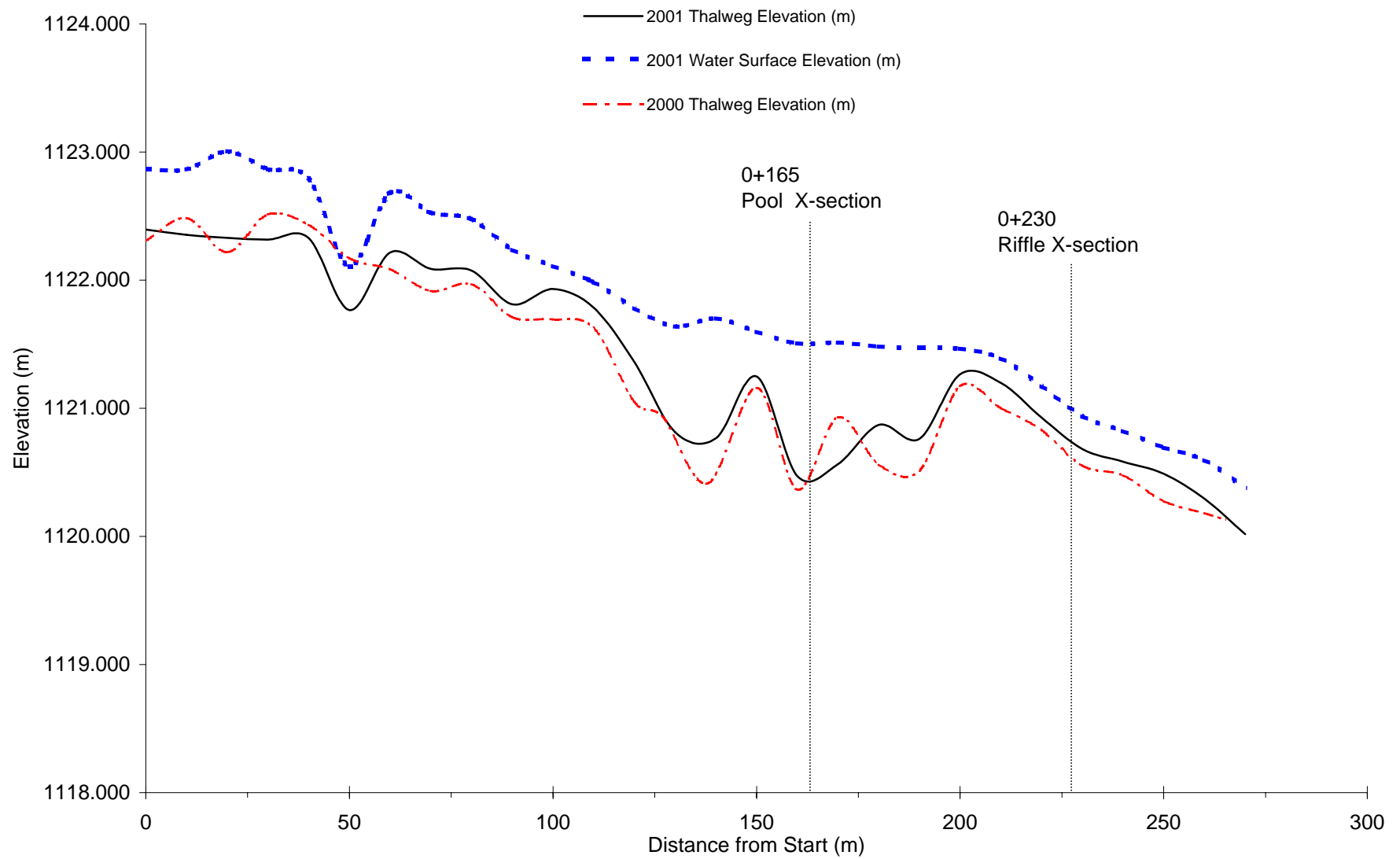
| | | | |
|-----------------------|--------|------------------------|---------|
| NTS Maps (1:50,000) : | 082G03 | BGGS Maps (1:20,000) : | 082G007 |
| | | | |

| Bed Material Type | | | | | | Total | Functional LWD | | | Cover | | | | Offchannel Habitat | | | Disturbance Indicators | | | Riparian Vegetation | | | Barriers |
|-------------------|----------|----------|------------|---------|--------|-----------|----------------|-----------|-------|--------------|----|--------------|---|--------------------|--------|------------|------------------------|---|---|---------------------|-----------|----------------|----------|
| Dom. | Sub-Dom. | D90 (mm) | Compaction | SG Type | SG Amt | LWD Tally | 10 - 20cm | 20 - 50cm | >50cm | Cover Type 1 | % | Cover Type 2 | % | Type | Access | Length (m) | 1 | 2 | 3 | Type | Structure | Canopy Closure | |
| B | C | 800 | | R | L | 19 | 15 | 1 | | B | 40 | LWD | 5 | | | | | | | M | MF | 1 | |

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|-----|--|---|---|---|---|---|--|---|----|---|---|--|--|--|--|--|--|---|----|---|--|
| C | B | 600 | | R | L | 5 | 4 | 1 | | B | 15 | C | 5 | | | | | | | M | MF | 1 | |
|---|---|-----|--|---|---|---|---|---|--|---|----|---|---|--|--|--|--|--|--|---|----|---|--|

Appendix D

FHAP Channel Survey Data



Longitudinal profile of a representative two meander lengths of Bighorn Creek in reach 1, study site 1.

Bighorn Long Survey

Longitudinal Survey

Location: Bighorn Creek

Reach: 1

Site: 1

UTM: 649255E, 5449395N

Crew: SC/KM

Date: 13/09/2001

Benchmark UTM:

BM2: 649256E, 5449358N

RP2: 649106E, 5449472N

RP3: 649150E, 5449385N

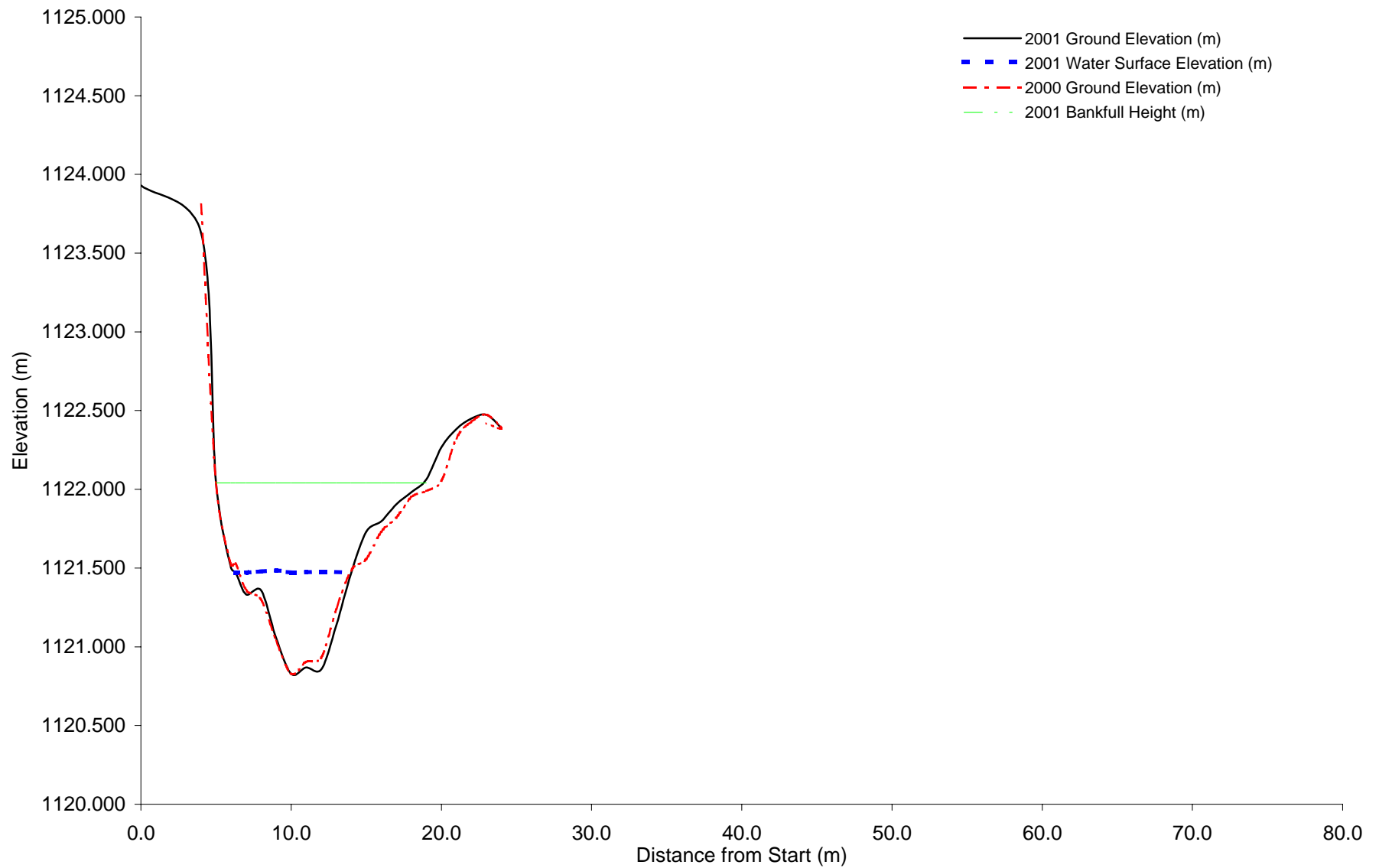
RP4: 649203E, 5449419N

Benchmark elevation:

BM2: 1124.459 RP3: 1121.934

RP2: 1120.448 RP4: 1123.364

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | | Dominant Substrate | Habitat Type | Comments |
|--------------------|-------------------------|-----------------------|-----------------|-----------------------------|-----------------------|-----------------------------|--------------------|--------------|-------------------------------------|
| | | Thalweg Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Thalweg Elevation (m) | Water Surface Elevation (m) | | | |
| BM2 | 0 | 2.559 | 0.470 | 2.089 | 1122.395 | 1122.865 | gravel | pool | LWD has accumulated since last year |
| | 10 | 2.600 | 0.510 | 2.090 | 1122.354 | 1122.864 | sand | pool | tertiary pool |
| | 20 | 2.624 | 0.675 | 1.949 | 1122.330 | 1123.005 | sand | pool | tertiary pool |
| | 30 | 2.637 | 0.549 | 2.088 | 1122.317 | 1122.866 | cobble | glide | |
| TP1 | 40 | 2.626 | 0.465 | 2.161 | 1122.328 | 1122.793 | gravel | glide | |
| | 50 | 2.717 | 0.340 | 2.377 | 1121.766 | 1122.106 | gravel | glide | |
| | 60 | 2.267 | 0.465 | 1.802 | 1122.216 | 1122.681 | gravel | riffle | one BT redd, LWD plunge pool |
| | 70 | 2.395 | 0.438 | 1.957 | 1122.088 | 1122.526 | gravel | riffle | LWD accumulation |
| | 80 | 2.409 | 0.403 | 2.006 | 1122.074 | 1122.477 | gravel | riffle | one BT redd at 0+73m |
| | 90 | 2.671 | 0.425 | 2.246 | 1121.812 | 1122.237 | gravel | riffle | nice cover |
| | 100 | 2.552 | 0.180 | 2.372 | 1121.931 | 1122.111 | gravel | riffle | |
| | 110 | 2.698 | 0.200 | 2.498 | 1121.785 | 1121.985 | gravel | riffle | corner |
| | 120 | 3.122 | 0.420 | 2.702 | 1121.361 | 1121.781 | gravel | pool | |
| | 130 | 3.669 | 0.825 | 2.844 | 1120.814 | 1121.639 | sand | pool | large log jam |
| | 140 | 3.716 | 0.935 | 2.781 | 1120.767 | 1121.702 | finer | pool | 1 BT, 1WCT |
| | 150 | 3.156 | 0.350 | 2.806 | 1121.248 | 1121.598 | gravel | pool | pool tailout, 3 BT, 1BT redd |
| | 160 | 3.933 | 1.035 | 2.898 | 1120.471 | 1121.506 | finer | pool | 3 BT (redds overnight) |
| | 170 | 3.841 | 0.950 | 2.891 | 1120.563 | 1121.513 | cobble | pool | |
| | 180 | 3.533 | 0.610 | 2.923 | 1120.871 | 1121.481 | finer | pool | |
| | 190 | 3.642 | 0.710 | 2.932 | 1120.762 | 1121.472 | gravel | pool | |
| | 200 | 3.138 | 0.200 | 2.938 | 1121.266 | 1121.466 | gravel | pool | tailout |
| | 210 | 1.867 | 0.190 | 1.677 | 1121.199 | 1121.389 | gravel | riffle | |
| | 220 | 2.139 | 0.245 | 1.894 | 1120.927 | 1121.172 | cobble | riffle | |
| | 230 | 2.384 | 0.255 | 2.129 | 1120.682 | 1120.937 | cobble | riffle | |
| | 240 | 2.482 | 0.240 | 2.242 | 1120.584 | 1120.824 | cobble | riffle | |
| | 250 | 2.577 | 0.205 | 2.372 | 1120.489 | 1120.694 | gravel | glide | one BT redd, LWD accumulation |
| | 260 | 2.771 | 0.300 | 2.471 | 1120.295 | 1120.595 | cobble | riffle | |
| | 270 | 3.048 | 0.360 | 2.688 | 1120.018 | 1120.378 | gravel | riffle | |



Cross sectional profile of a representative pool habitat unit of Bighorn Creek in reach 1, study site 1.

Bighorn Pool X-Sxn

Pool Cross Sectional Survey

Location: Bighorn Creek

Reach: 1

Site: 1

pool cross section located at 0+165 m from start of longitudinal survey

UTM: 649147E, 5449379N

Crew: KM/SC

Date: 14/09/2001

Benchmark UTM:

BM2: 649256E, 5449358N

RP3: 649150E, 5449385N

RP4: 649203E, 5449419N

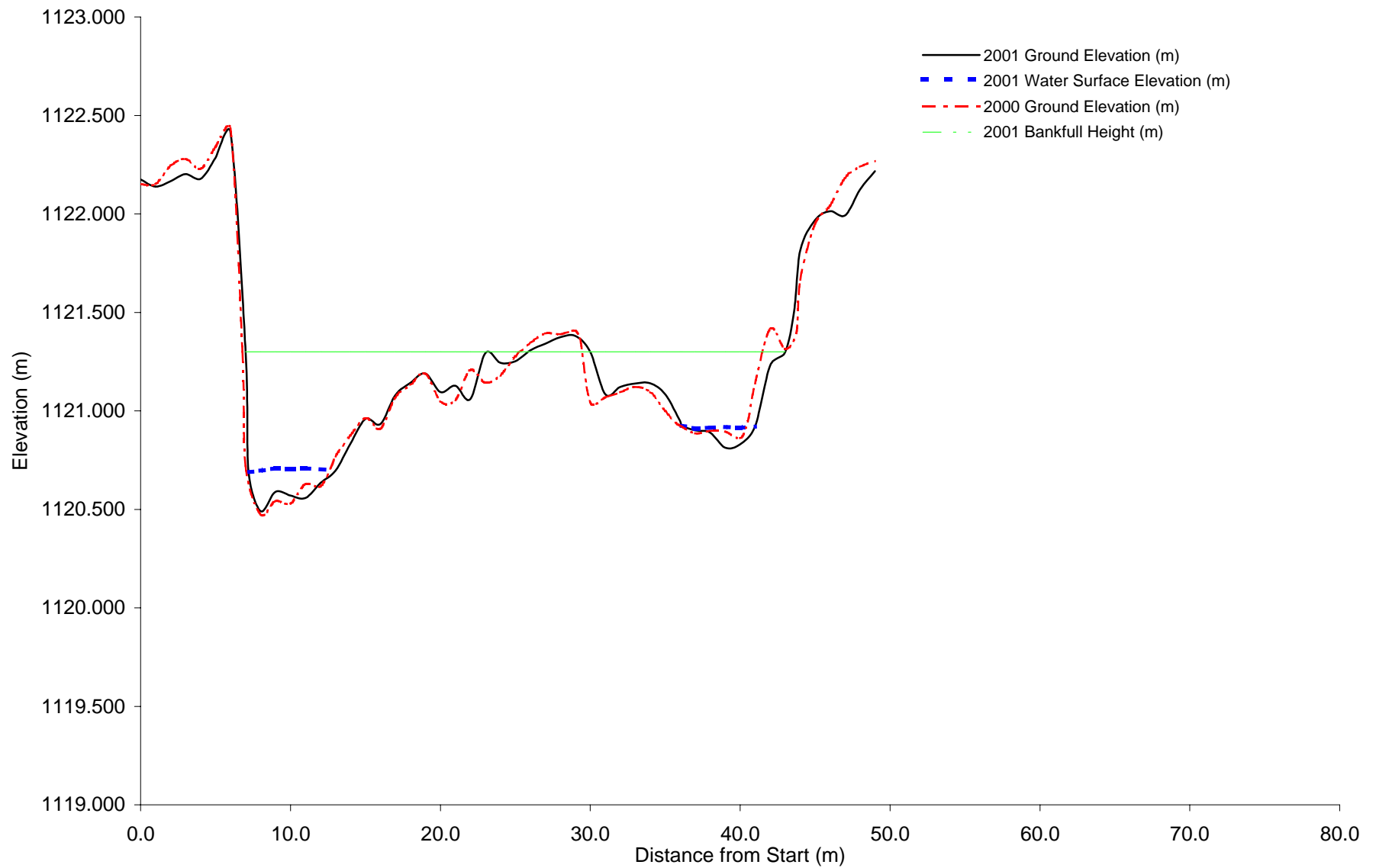
Benchmark elevation:

BM2: 1124.459

RP3: 1122.038

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | | Corrected Data | | Dominant Substrate | Comments |
|-----------------------|----------------------------|------------------|--------------------|--------------------------------|-------------------------|--------------------------------|-----------------------|--|
| | | Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | Water Surface Elevation (m) | | |
| RP3* | 0.0 | 0.150 | | | 1123.930 | | vegetation | top of RUB bank |
| | 4.0 | 0.452 | | | 1123.628 | | vegetation | |
| | 5.0 | 2.040 | | | 1122.040 | | vegetation | RUB bankfull height |
| | 6.0 | 2.578 | | | 1121.502 | | vegetation | |
| | 6.3 | 2.608 | 0.000 | 2.608 | 1121.472 | 1121.472 | clay | RUB wetted edge |
| | 7.0 | 2.748 | 0.140 | 2.608 | 1121.332 | 1121.472 | clay | |
| | 8.0 | 2.722 | 0.120 | 2.602 | 1121.358 | 1121.478 | clay | |
| | 9.0 | 3.021 | 0.425 | 2.596 | 1121.059 | 1121.484 | clay | LWD in channel |
| | 10.0 | 3.252 | 0.644 | 2.608 | 1120.828 | 1121.472 | clay | maximum pool depth, BT in pool |
| | 11.0 | 3.211 | 0.605 | 2.606 | 1120.869 | 1121.474 | clay | new redds overnight |
| | 12.0 | 3.223 | 0.620 | 2.603 | 1120.857 | 1121.477 | gravel | |
| | 13.0 | 2.945 | 0.340 | 2.605 | 1121.135 | 1121.475 | gravel | |
| | 14.0 | 2.613 | 0.000 | 2.613 | 1121.467 | 1121.467 | gravel | LUB wetted edge |
| | 15.0 | 2.349 | | | 1121.731 | | sand | |
| | 16.0 | 2.283 | | | 1121.797 | | sand | |
| | 17.0 | 2.176 | | | 1121.904 | | sand | |
| | 18.0 | 2.099 | | | 1121.981 | | sand | |
| | 19.0 | 2.018 | | | 1122.062 | | cobble | LUB bankfull height, vegetation on bar |
| | 20.0 | 1.812 | | | 1122.268 | | cobble | |
| | 21.0 | 1.697 | | | 1122.383 | | gravel | |
| | 22.0 | 1.631 | | | 1122.449 | | gravel | |
| | 23.0 | 1.607 | | | 1122.473 | | sand | |
| | 24.0 | 1.689 | | | 1122.391 | | sand | |

*RP3 backsight = 2.042, height of instrument = 1124.08 m



Cross sectional profile of a representative riffle habitat unit of the Bighorn Creek in reach 1, study site 1.

Bighorn Riffle X-Sxn

Riffle Cross Sectional Survey

Location: Bighorn Creek

Reach: 1

Site: 1

riffle cross section located at 0+230 m of longitudinal survey

UTM: 649102E, 5449417N

Crew: KM/SC

Date: 14/09/2001

Benchmark UTM:

BM2: 649106E, 5449472N

RP3: 649150E, 5449385N

Benchmark elevations:

BM2: 1124.459

RP3: 1122.038

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | | Corrected Data | | Dominant Substrate | Comments | |
|-----------------------|----------------------------|-------------------------|--------------------|--------------------------------|-------------------------|--------------------------------|-----------------------|------------------------------------|--------|
| | | Ground Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | Water Surface Elevation (m) | | | |
| RP3* | 0.0 | 0.677 | | | 1122.175 | | vegetation | RUB pin | |
| | 1.0 | 0.713 | | | 1122.139 | | vegetation | | |
| | 2.0 | 0.686 | | | 1122.166 | | vegetation | | |
| | 3.0 | 0.650 | | | 1122.202 | | vegetation | | |
| | 4.0 | 0.673 | | | 1122.179 | | vegetation | | |
| | 5.0 | 0.567 | | | 1122.285 | | vegetation | | |
| | 6.0 | 0.438 | | | 1122.414 | | vegetation | undercut bank | |
| | 7.0 | 1.552 | | | 1121.300 | | vegetation | RUB bankfull height, undercut bank | 1121.3 |
| | 7.2 | 2.163 | 0.000 | 2.163 | 1120.689 | 1120.689 | gravel | RUB wetted edge | 1121.3 |
| | 8.0 | 2.361 | 0.205 | 2.156 | 1120.491 | 1120.696 | gravel | thalweg | 1121.3 |
| | 9.0 | 2.264 | 0.120 | 2.144 | 1120.588 | 1120.708 | gravel | | 1121.3 |
| | 10.0 | 2.282 | 0.135 | 2.147 | 1120.570 | 1120.705 | gravel | | 1121.3 |
| | 11.0 | 2.294 | 0.150 | 2.144 | 1120.558 | 1120.708 | gravel | | 1121.3 |
| | 12.0 | 2.218 | 0.070 | 2.148 | 1120.634 | 1120.704 | gravel | | 1121.3 |
| | 13.0 | 2.155 | 0.000 | 2.155 | 1120.697 | 1120.697 | gravel | LUB wetted edge | 1121.3 |
| | 14.0 | 2.019 | | | 1120.833 | | gravel | vegetated bar | 1121.3 |
| | 15.0 | 1.893 | | | 1120.959 | | gravel | vegetated bar | 1121.3 |
| | 16.0 | 1.919 | | | 1120.933 | | gravel | vegetated bar | 1121.3 |
| | 17.0 | 1.773 | | | 1121.079 | | gravel | | 1121.3 |
| | 18.0 | 1.709 | | | 1121.143 | | cobble | | 1121.3 |
| | 19.0 | 1.663 | | | 1121.189 | | cobble | | 1121.3 |
| | 20.0 | 1.757 | | | 1121.095 | | cobble | | 1121.3 |
| | 21.0 | 1.724 | | | 1121.128 | | cobble | | 1121.3 |
| | 22.0 | 1.792 | | | 1121.060 | | cobble | | 1121.3 |
| | 23.0 | 1.558 | | | 1121.294 | | cobble | | 1121.3 |
| | 24.0 | 1.608 | | | 1121.244 | | cobble | | 1121.3 |
| | 25.0 | 1.601 | | | 1121.251 | | cobble | | 1121.3 |
| | 26.0 | 1.545 | | | 1121.307 | | cobble | LUB bankfull height | 1121.3 |
| | 27.0 | 1.511 | | | 1121.341 | | cobble | | 1121.3 |
| | 28.0 | 1.478 | | | 1121.374 | | cobble | | 1121.3 |
| | 29.0 | 1.472 | | | 1121.380 | | cobble | | 1121.3 |
| | 30.0 | 1.552 | | | 1121.300 | | cobble | | 1121.3 |

Bighorn Riffle X-Sxn

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | Dominant Substrate | Comments | |
|-----------------------|----------------------------|-------------------------|--------------------|--------------------------------|-------------------------|--------------------------------|----------|------------------------------|
| | | Ground Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | Water Surface Elevation (m) | | |
| | 31.0 | 1.768 | | | 1121.084 | | cobble | 1121.3 |
| | 32.0 | 1.730 | | | 1121.122 | | cobble | 1121.3 |
| | 33.0 | 1.713 | | | 1121.139 | | gravel | 1121.3 |
| | 34.0 | 1.712 | | | 1121.140 | | gravel | 1121.3 |
| | 35.0 | 1.768 | | | 1121.084 | | gravel | 1121.3 |
| | 36.0 | 1.906 | | | 1120.946 | | gravel | 1121.3 |
| | 36.1 | 1.928 | 0.000 | 1.928 | 1120.924 | 1120.924 | gravel | wetted edge 1121.3 |
| | 37.0 | 1.951 | 0.010 | 1.941 | 1120.901 | 1120.911 | gravel | 1121.3 |
| | 38.0 | 1.962 | 0.025 | 1.937 | 1120.890 | 1120.915 | gravel | unvegetated bar 1121.3 |
| | 39.0 | 2.039 | 0.105 | 1.934 | 1120.813 | 1120.918 | gravel | 1121.3 |
| | 40.0 | 2.022 | 0.085 | 1.937 | 1120.830 | 1120.915 | gravel | 1121.3 |
| | 41.0 | 1.931 | 0.000 | 1.931 | 1120.921 | 1120.921 | cobble | LUB wetted edge 1121.3 |
| | 42.0 | 1.621 | | | 1121.231 | | cobble | 1121.3 |
| | 43.0 | 1.554 | | | 1121.298 | | gravel | LUB bankfull height 1121.3 |
| | 43.6 | 1.346 | | | 1121.506 | | gravel | unvegetated bar |
| | 44.0 | 1.038 | | | 1121.814 | | gravel | |
| | 45.0 | 0.883 | | | 1121.969 | | gravel | start of riparian vegetation |
| | 46.0 | 0.838 | | | 1122.014 | | | |
| | 47.0 | 0.859 | | | 1121.993 | | | |
| | 48.0 | 0.728 | | | 1122.124 | | | |
| | 49.0 | 0.635 | | | 1122.217 | | | LUB Pin |

14, height of instrument = 1122.852

Bighorn Differential Level Loop

Bighorn Creek

Differential Levelling Loop - Reach 1, Site 1

Date: 14/09/2001

Field (Arbitrary) Elevations (m)

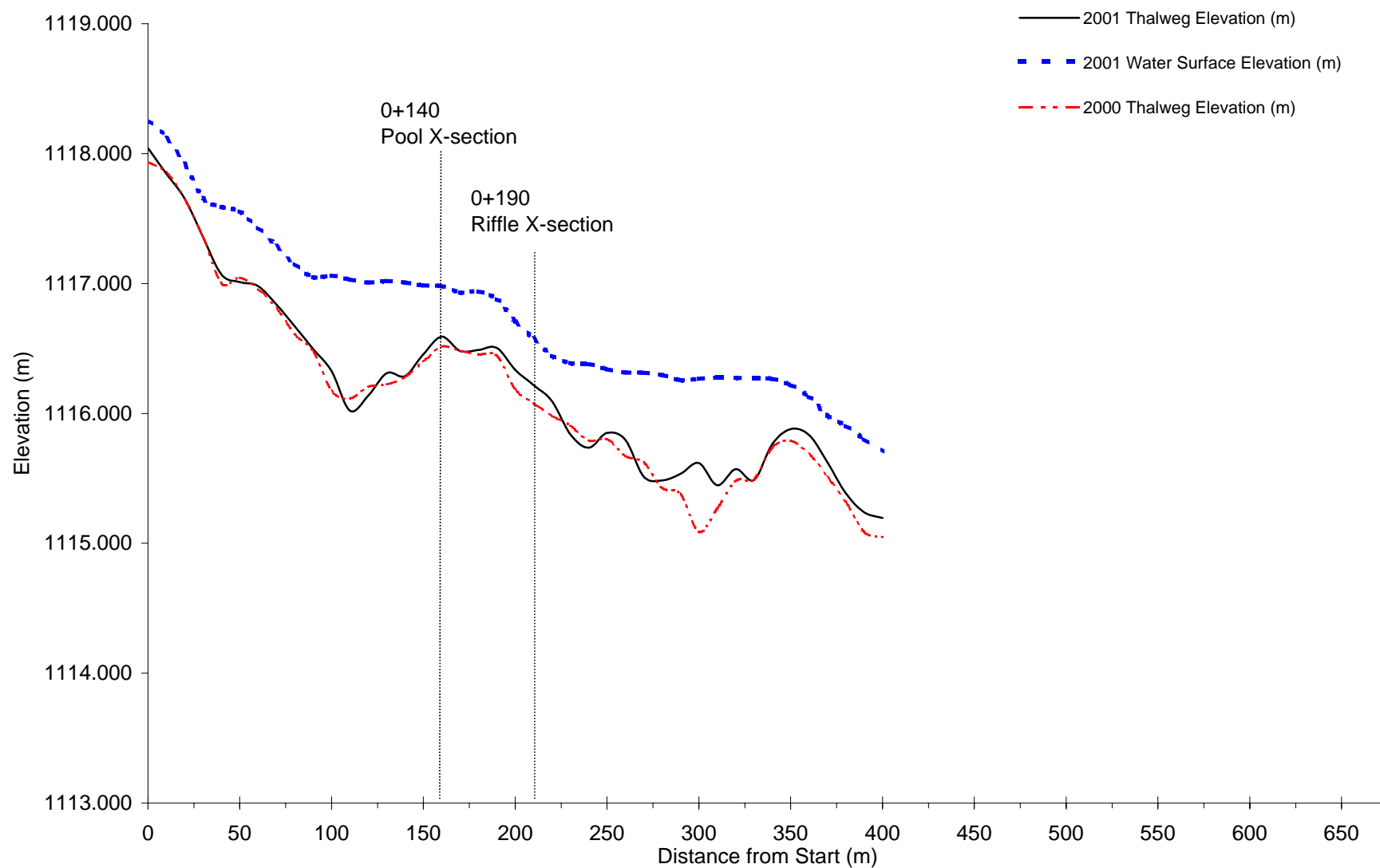
| Station | Backsight | Height of Instrument | Foresight | Elevation |
|---------|-----------|-------------------------|-----------|---------------|
| BM2 | 0.495 | 5.495 | | 5.000 |
| TP1 | 1.013 | 5.024 | 1.484 | 4.011 |
| RP4 | 1.018 | 4.945 | 1.097 | 3.927 |
| RP3 | 1.031 | 3.607 | 2.369 | 2.576 |
| RP2 | | | 2.471 | 1.136 |
| RP2 | 2.505 | 3.641 | | 1.136 |
| RP3 | 2.366 | 4.948 | 1.059 | 2.582 |
| RP4 | 1.092 | 5.026 | 1.014 | 3.934 |
| TP1 | 1.475 | 5.481 | 1.02 | 4.006 |
| BM2 | | | 0.484 | 4.997 |
| | | | | error= -0.003 |

True Elevations (m)

| Station | Backsight | Height of Instrument | Foresight | Elevation |
|---------|-----------|-------------------------|-----------|---------------|
| BM2 | 0.495 | 1124.954 | | 1124.459 |
| TP1 | 1.013 | 1124.483 | 1.484 | 1123.470 |
| RP4 | 1.018 | 1124.404 | 1.097 | 1123.386 |
| RP3 | 1.031 | 1123.066 | 2.369 | 1122.035 |
| RP2 | | | 2.471 | 1120.595 |
| RP2 | 2.505 | 1123.100 | | 1120.595 |
| RP3 | 2.366 | 1124.407 | 1.059 | 1122.041 |
| RP4 | 1.092 | 1124.485 | 1.014 | 1123.393 |
| TP1 | 1.475 | 1124.940 | 1.02 | 1123.465 |
| BM2 | | | 0.484 | 1124.456 |
| | | | | error= -0.003 |

| Benchmark Elevations (m) | | |
|--------------------------|----------|----------|
| | 2000 | 2001 |
| BM2 | 1124.459 | 1124.459 |
| RP2 | 1120.448 | 1120.595 |
| RP3 | 1121.934 | 1122.038 |
| RP4 | 1123.364 | 1123.39 |

(BM2 elevation from 1999 survey)



Longitudinal profile of a representative two meander lengths of the Wigwam River in reach 5, study site 1.

Reach 5, Site 1 Long Survey

Longitudinal Survey

Location: Wigwam River

Reach: 5

Site: 1

UTM: start 648335E, 5449685N

end 648110E, 5449910N

Crew: SC/KM

Date: 17/09/2001

Benchmark UTM:

BM1: 648333E, 5449663N

BM2: 648108E, 5449915N

Benchmark Elevations:

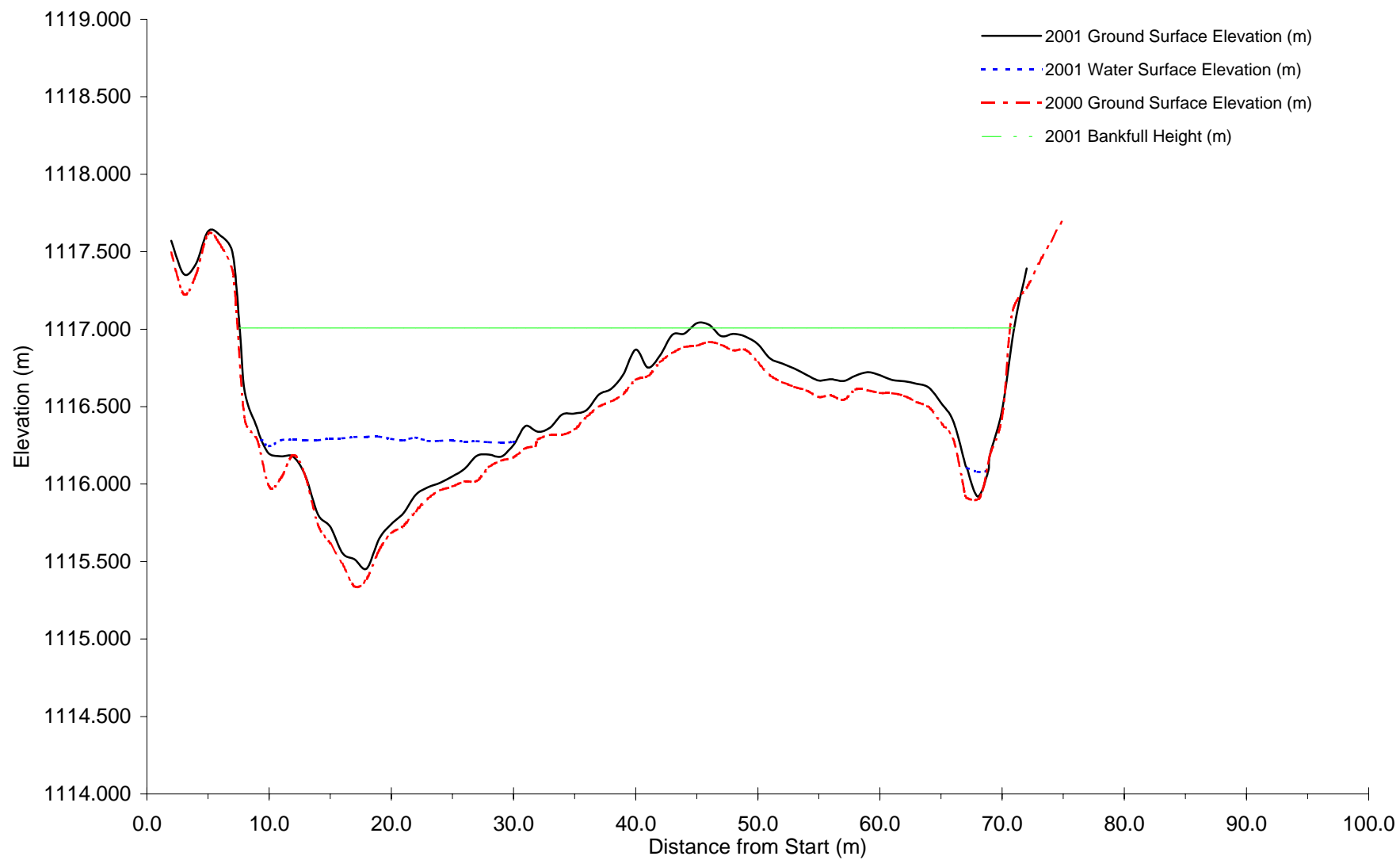
BM1: 1120.000

BM2: 1116.955

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | | Corrected Data | | Dominant Substrate | Habitat Type | Comments |
|-----------------------|----------------------------|--------------------------|--------------------|--------------------------------|--------------------------|--------------------------------|-----------------------|-----------------|----------------|
| | | Thalweg Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Thalweg Elevation (m) | Water Surface Elevation (m) | | | |
| BM1 | 0 | 2.039 | 0.215 | 1.824 | 1118.043 | 1118.258 | cobble | riffle | |
| | 10 | 2.238 | 0.275 | 1.963 | 1117.844 | 1118.119 | cobble | riffle | |
| | 20 | 2.431 | 0.270 | 2.161 | 1117.651 | 1117.921 | cobble | riffle | |
| | 30 | 2.727 | 0.300 | 2.427 | 1117.355 | 1117.655 | cobble | riffle | |
| | 40 | 3.013 | 0.520 | 2.493 | 1117.069 | 1117.589 | cobble | riffle | |
| | 50 | 3.071 | 0.545 | 2.526 | 1117.011 | 1117.556 | cobble | riffle | |
| | 60 | 3.102 | 0.450 | 2.652 | 1116.980 | 1117.430 | boulder | riffle | |
| | 70 | 3.244 | 0.450 | 2.794 | 1116.838 | 1117.288 | boulder | riffle | |
| | 80 | 3.412 | 0.481 | 2.931 | 1116.670 | 1117.151 | boulder | riffle | |
| | 90 | 3.588 | 0.554 | 3.034 | 1116.494 | 1117.048 | cobble | riffle | |
| TP1 | 100 | 3.756 | 0.735 | 3.021 | 1116.326 | 1117.061 | cobble | riffle | |
| | 110 | 2.679 | 1.010 | 1.669 | 1116.020 | 1117.030 | gravel | pool | ~10 BT in pool |
| | 120 | 2.561 | 0.870 | 1.691 | 1116.138 | 1117.008 | boulder | pool | |
| | 130 | 2.39 | 0.710 | 1.680 | 1116.309 | 1117.019 | boulder | pool | |
| | 140 | 2.411 | 0.720 | 1.691 | 1116.288 | 1117.008 | boulder | pool | pool tail out |
| | 150 | 2.244 | 0.530 | 1.714 | 1116.455 | 1116.985 | cobble | glide | |
| | 160 | 2.109 | 0.390 | 1.719 | 1116.590 | 1116.980 | cobble | glide | |
| | 170 | 2.219 | 0.450 | 1.769 | 1116.480 | 1116.930 | cobble | riffle | |
| | 180 | 2.211 | 0.450 | 1.761 | 1116.488 | 1116.938 | cobble | riffle | |
| | 190 | 2.195 | 0.375 | 1.820 | 1116.504 | 1116.879 | cobble | riffle | |
| | 200 | 2.363 | 0.370 | 1.993 | 1116.336 | 1116.706 | cobble | riffle | |
| | 210 | 2.482 | 0.360 | 2.122 | 1116.217 | 1116.577 | cobble | riffle | |
| | 220 | 2.606 | 0.350 | 2.256 | 1116.093 | 1116.443 | cobble | riffle | |
| | 230 | 2.861 | 0.550 | 2.311 | 1115.838 | 1116.388 | cobble | riffle | |
| | 240 | 2.964 | 0.645 | 2.319 | 1115.735 | 1116.380 | cobble | riffle | |
| | 250 | 2.849 | 0.490 | 2.359 | 1115.850 | 1116.340 | cobble | riffle | |
| | 260 | 2.903 | 0.520 | 2.383 | 1115.796 | 1116.316 | cobble | riffle | |

Reach 5, Site 1 Long Survey

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | | Corrected Data | | Dominant Substrate | Habitat Type | Comments |
|-----------------------|----------------------------|--------------------------|--------------------|--------------------------------|--------------------------|--------------------------------|-----------------------|-----------------|----------------|
| | | Thalweg Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Thalweg Elevation (m) | Water Surface Elevation (m) | | | |
| TP2 | 270 | 2.709 | 0.800 | 1.909 | 1115.513 | 1116.313 | cobble | glide | |
| | 280 | 2.737 | 0.810 | 1.927 | 1115.485 | 1116.295 | cobble | pool | |
| | 290 | 2.686 | 0.720 | 1.966 | 1115.536 | 1116.256 | cobble | glide | |
| | 300 | 2.605 | 0.650 | 1.955 | 1115.617 | 1116.267 | cobble | glide | |
| | 310 | 2.776 | 0.830 | 1.946 | 1115.446 | 1116.276 | cobble | pool | |
| | 320 | 2.652 | 0.705 | 1.947 | 1115.570 | 1116.275 | cobble | pool | ~77 BT in pool |
| | 330 | 2.733 | 0.782 | 1.951 | 1115.489 | 1116.271 | cobble | glide | |
| | 340 | 2.458 | 0.502 | 1.956 | 1115.764 | 1116.266 | cobble | glide | |
| | 350 | 2.343 | 0.340 | 2.003 | 1115.879 | 1116.219 | cobble | glide | |
| | 360 | 2.389 | 0.295 | 2.094 | 1115.833 | 1116.128 | cobble | riffle | |
| | 370 | 2.598 | 0.360 | 2.238 | 1115.624 | 1115.984 | cobble | riffle | |
| TP3 | 380 | 2.843 | 0.520 | 2.323 | 1115.385 | 1115.905 | cobble | riffle | |
| | 390 | 2.99 | 0.565 | 2.425 | 1115.238 | 1115.803 | boulder | riffle | |
| | 400 | 3.032 | 0.510 | 2.522 | 1115.196 | 1115.706 | boulder | riffle | |



Cross sectional profile of a representative pool habitat unit of the Wigwam River in reach 5, study site 1

Reach 5, Site 1 Pool X- Sxn

Pool Cross Sectional Survey

Location: Wigwam River

Reach: 5

Site: 1

UTM: 648080E, 5449780N

Crew: KM/LC

Date: 25/09/2001

Benchmark UTM:

BM1: 648333E, 5449663N

BM2: 648108E, 5449915N

pool cross section location at 0+140m of longitudinal profile

Benchmark Elevations:

BM2 1116.955

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | Dominant Substrate | Comments |
|-----------------------|----------------------------|------------------|--------------------|--------------------------------|-------------------------|--------------------------------|------------------------------------|
| | | Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | Water Surface Elevation (m) | |
| BM2* | 2.0 | 1.075 | | | 1117.571 | | vegetation RUB bank, riparian veg. |
| | 3.0 | 1.290 | | | 1117.356 | | vegetation |
| | 4.0 | 1.226 | | | 1117.420 | | vegetation |
| | 5.0 | 1.014 | | | 1117.632 | | vegetation |
| | 6.0 | 1.041 | | | 1117.605 | | vegetation |
| | 7.0 | 1.148 | | | 1117.498 | | vegetation |
| | 7.6 | 1.639 | | | 1117.007 | | vegetation bankfull height |
| | 8.0 | 2.053 | | | 1116.593 | | vegetation |
| | 9.0 | 2.280 | | | 1116.366 | | fines |
| | 9.4 | 2.361 | 0 | 2.361 | 1116.285 | 1116.285 | cobble RUB wetted edge |
| | 10.0 | 2.451 | 0.05 | 2.401 | 1116.195 | 1116.245 | fines |
| | 11.0 | 2.467 | 0.105 | 2.362 | 1116.179 | 1116.284 | fines |
| | 12.0 | 2.470 | 0.11 | 2.36 | 1116.176 | 1116.286 | gravel |
| | 13.0 | 2.597 | 0.235 | 2.362 | 1116.049 | 1116.284 | cobble |
| | 14.0 | 2.843 | 0.48 | 2.363 | 1115.803 | 1116.283 | fines |
| | 15.0 | 2.921 | 0.57 | 2.351 | 1115.725 | 1116.295 | fines |
| | 16.0 | 3.091 | 0.74 | 2.351 | 1115.555 | 1116.295 | cobble |
| | 17.0 | 3.132 | 0.79 | 2.342 | 1115.514 | 1116.304 | cobble |
| | 18.0 | 3.191 | 0.85 | 2.341 | 1115.455 | 1116.305 | cobble |
| | 19.0 | 2.999 | 0.66 | 2.339 | 1115.647 | 1116.307 | cobble |
| | 20.0 | 2.904 | 0.55 | 2.354 | 1115.742 | 1116.292 | cobble |
| | 21.0 | 2.833 | 0.47 | 2.363 | 1115.813 | 1116.283 | cobble |
| | 22.0 | 2.715 | 0.37 | 2.345 | 1115.931 | 1116.301 | cobble |
| | 23.0 | 2.667 | 0.3 | 2.367 | 1115.979 | 1116.279 | cobble |
| | 24.0 | 2.637 | 0.27 | 2.367 | 1116.009 | 1116.279 | cobble |
| | 25.0 | 2.596 | 0.23 | 2.366 | 1116.050 | 1116.280 | cobble |
| | 26.0 | 2.547 | 0.175 | 2.372 | 1116.099 | 1116.274 | cobble |
| | 27.0 | 2.463 | 0.095 | 2.368 | 1116.183 | 1116.278 | gravel |
| | 28.0 | 2.455 | 0.08 | 2.375 | 1116.191 | 1116.271 | cobble |
| | 29.0 | 2.468 | 0.09 | 2.378 | 1116.178 | 1116.268 | cobble |
| | 30.0 | 2.394 | 0.02 | 2.374 | 1116.252 | 1116.272 | cobble |

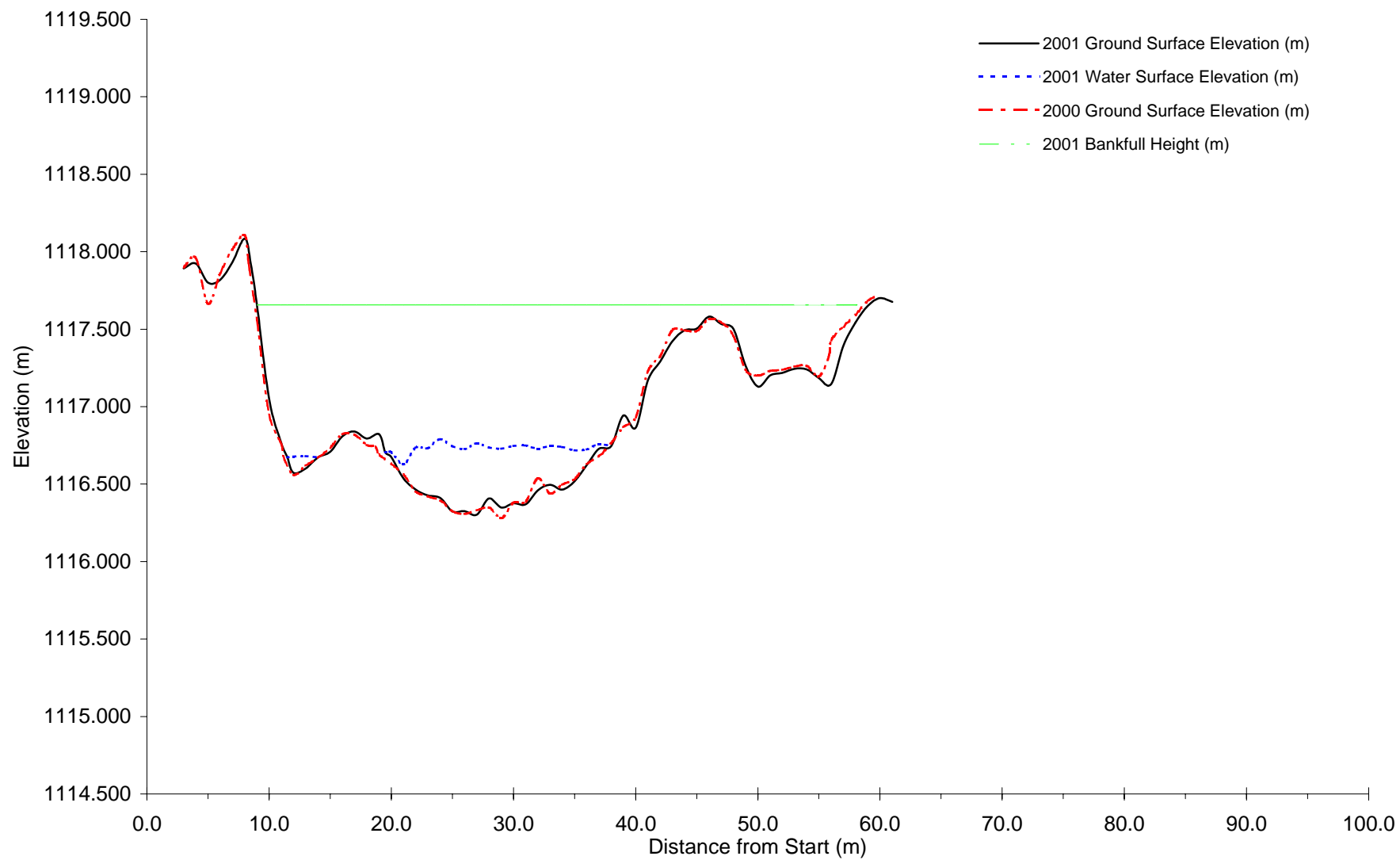
Reach 5, Site 1 Pool X- Sxn

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | Dominant Substrate | Comments |
|-----------------------|----------------------------|------------------|--------------------|--------------------------------|-------------------------|--------------------------------|--------------------------|
| | | Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | Water Surface Elevation (m) | |
| | 30.2 | 2.369 | 0 | 2.369 | 1116.277 | 1116.277 | LUB wetted edge |
| | 31.0 | 2.271 | | | 1116.375 | | cobble |
| | 32.0 | 2.308 | | | 1116.338 | | cobble |
| | 33.0 | 2.282 | | | 1116.364 | | vegetation |
| | 34.0 | 2.196 | | | 1116.450 | | vegetation |
| | 35.0 | 2.191 | | | 1116.455 | | cobble |
| | 36.0 | 2.167 | | | 1116.479 | | cobble |
| | 37.0 | 2.068 | | | 1116.578 | | cobble |
| | 38.0 | 2.032 | | | 1116.614 | | cobble |
| | 39.0 | 1.938 | | | 1116.708 | | cobble |
| | 40.0 | 1.777 | | | 1116.869 | | cobble |
| | 41.0 | 1.894 | | | 1116.752 | | cobble |
| | 42.0 | 1.815 | | | 1116.831 | | cobble |
| | 43.0 | 1.682 | | | 1116.964 | | cobble |
| | 44.0 | 1.675 | | | 1116.971 | | cobble |
| | 45.0 | 1.607 | | | 1117.039 | | cobble |
| | 46.0 | 1.618 | | | 1117.028 | | cobble |
| | 47.0 | 1.691 | | | 1116.955 | | cobble |
| | 48.0 | 1.676 | | | 1116.970 | | cobble |
| | 49.0 | 1.694 | | | 1116.952 | | cobble |
| | 50.0 | 1.743 | | | 1116.903 | | cobble |
| | 51.0 | 1.835 | | | 1116.811 | | cobble |
| | 52.0 | 1.867 | | | 1116.779 | | cobble |
| | 53.0 | 1.900 | | | 1116.746 | | gravel |
| | 54.0 | 1.941 | | | 1116.705 | | gravel |
| | 55.0 | 1.978 | | | 1116.668 | | cobble |
| | 56.0 | 1.970 | | | 1116.676 | | cobble |
| | 57.0 | 1.981 | | | 1116.665 | | cobble |
| | 58.0 | 1.946 | | | 1116.700 | | cobble |
| | 59.0 | 1.923 | | | 1116.723 | | cobble |
| | 60.0 | 1.943 | | | 1116.703 | | cobble |
| | 61.0 | 1.974 | | | 1116.672 | | cobble |
| | 62.0 | 1.982 | | | 1116.664 | | cobble |
| | 63.0 | 1.998 | | | 1116.648 | | cobble |
| | 64.0 | 2.023 | | | 1116.623 | | cobble |
| | 65.0 | 2.122 | | | 1116.524 | | cobble |
| | 66.0 | 2.242 | | | 1116.404 | | cobble |
| | 67.0 | 2.528 | | | 1116.118 | | cobble |
| | 67.1 | 2.542 | 0 | 2.542 | 1116.104 | 1116.104 | side channel wetted edge |
| | 68.0 | 2.726 | 0.16 | 2.566 | 1115.920 | 1116.080 | cobble |

Reach 5, Site 1 Pool X- Sxn

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | Dominant Substrate | Comments |
|-----------------------|----------------------------|------------------|--------------------|--------------------------------|-------------------------|--------------------------------|--|
| | | Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | Water Surface Elevation (m) | |
| | 68.9 | 2.564 | 0 | 2.564 | 1116.082 | 1116.082 | cobble side channel wetted edge |
| | 69.0 | 2.457 | | | 1116.189 | | cobble |
| | 70.0 | 2.168 | | | 1116.478 | | finer |
| | 71.0 | 1.634 | | | 1117.012 | | vegetation bankfull height, riparian veg |
| | 72.0 | 1.253 | | | 1117.393 | | vegetation |

*BM2 backsight = 1.691, height of instrument = 1118.646



Cross sectional profile of a representative riffle habitat unit of the Wigwam River in reach 5, study site 1

Reach 5, Site 1 Riffle X-Sxn

Riffle Cross Sectional Survey

Location: Wigwam River

Reach: 5

Site: 1

UTM: 648156E, 5449814 N

Crew: SC/KM

Date: 17/09/2001

Benchmark UTM:

BM1: 648333E, 5449663N

BM2: 648108E, 5449915N

Benchmark elevations:

TP1: 1117.994

riffle cross section location at 0+190 m of longitudinal profile

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | Dominant Substrate | Comments |
|-----------------------|----------------------------|------------------|--------------------|--------------------------------|-------------------------|--------------------------------|------------------------|
| | | Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | Water Surface Elevation (m) | |
| TP1* | 3.0 | 0.609 | | | 1117.893 | | vegetation |
| | 4.0 | 0.579 | | | 1117.923 | | |
| | 5.0 | 0.702 | | | 1117.800 | | |
| | 6.0 | 0.683 | | | 1117.819 | | |
| | 7.0 | 0.570 | | | 1117.932 | | |
| | 8.0 | 0.417 | | | 1118.085 | | |
| | 8.5 | 0.584 | | | 1117.918 | | cobble |
| | 9.0 | 0.846 | | | 1117.656 | | cobble bankfull height |
| | 10.0 | 1.451 | | | 1117.051 | | cobble |
| | 11.0 | 1.738 | | | 1116.764 | | cobble |
| | 11.5 | 1.829 | 0 | 1.829 | 1116.673 | 1116.673 | cobble wetted edge |
| | 12.0 | 1.929 | 0.105 | 1.824 | 1116.573 | 1116.678 | cobble |
| | 13.0 | 1.901 | 0.08 | 1.821 | 1116.601 | 1116.681 | cobble |
| | 14.0 | 1.829 | 0 | 1.829 | 1116.673 | 1116.673 | cobble wetted edge |
| | 15.0 | 1.794 | | | 1116.708 | | cobble |
| | 16.0 | 1.693 | | | 1116.809 | | gravel |
| | 17.0 | 1.663 | | | 1116.839 | | gravel |
| | 18.0 | 1.709 | | | 1116.793 | | gravel |
| | 19.0 | 1.680 | | | 1116.822 | | gravel |
| | 19.5 | 1.797 | 0 | 1.797 | 1116.705 | 1116.705 | gravel wetted edge |
| | 20.0 | 1.827 | 0.03 | 1.797 | 1116.675 | 1116.705 | cobble |
| | 21.0 | 1.966 | 0.09 | 1.876 | 1116.536 | 1116.626 | cobble |
| | 22.0 | 2.037 | 0.27 | 1.767 | 1116.465 | 1116.735 | cobble |
| | 23.0 | 2.075 | 0.305 | 1.770 | 1116.427 | 1116.732 | cobble |
| | 24.0 | 2.091 | 0.38 | 1.711 | 1116.411 | 1116.791 | cobble |
| | 25.0 | 2.178 | 0.42 | 1.758 | 1116.324 | 1116.744 | cobble |
| | 26.0 | 2.176 | 0.4 | 1.776 | 1116.326 | 1116.726 | cobble |
| | 27.0 | 2.199 | 0.46 | 1.739 | 1116.303 | 1116.763 | cobble |
| | 28.0 | 2.095 | 0.33 | 1.765 | 1116.407 | 1116.737 | cobble |
| | 29.0 | 2.153 | 0.38 | 1.773 | 1116.349 | 1116.729 | cobble |
| | 30.0 | 2.126 | 0.37 | 1.756 | 1116.376 | 1116.746 | cobble |
| | 31.0 | 2.133 | 0.38 | 1.753 | 1116.369 | 1116.749 | cobble |
| | 32.0 | 2.043 | 0.27 | 1.773 | 1116.459 | 1116.729 | cobble |

Reach 5, Site 1 Riffle X-Sxn

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | | Dominant Substrate | Comments |
|-----------------------|----------------------------|------------------|--------------------|--------------------------------|-------------------------|--------------------------------|-----------------------|----------------|
| | | Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | Water Surface Elevation (m) | | |
| | 33.0 | 2.006 | 0.25 | 1.756 | 1116.496 | 1116.746 | cobble | |
| | 34.0 | 2.038 | 0.275 | 1.763 | 1116.464 | 1116.739 | cobble | |
| | 35.0 | 1.984 | 0.2 | 1.784 | 1116.518 | 1116.718 | cobble | |
| | 36.0 | 1.879 | 0.1 | 1.779 | 1116.623 | 1116.723 | cobble | |
| | 37.0 | 1.773 | 0.03 | 1.743 | 1116.729 | 1116.759 | cobble | |
| | 38.0 | 1.758 | 0 | 1.758 | 1116.744 | 1116.744 | cobble | wetted edge |
| | 39.0 | 1.559 | | | 1116.943 | | cobble | |
| | 40.0 | 1.638 | | | 1116.864 | | boulder | |
| | 41.0 | 1.331 | | | 1117.171 | | boulder | start log jam |
| | 42.0 | 1.212 | | | 1117.290 | | sand | logjam |
| | 43.0 | 1.082 | | | 1117.420 | | sand | end log jam |
| | 44.0 | 1.009 | | | 1117.493 | | sand | |
| | 45.0 | 0.998 | | | 1117.504 | | sand | |
| | 46.0 | 0.921 | | | 1117.581 | | gravel | |
| | 47.0 | 0.969 | | | 1117.533 | | sand | |
| | 48.0 | 0.999 | | | 1117.503 | | sand | |
| | 49.0 | 1.237 | | | 1117.265 | | sand | |
| | 50.0 | 1.372 | | | 1117.130 | | sand | |
| | 51.0 | 1.300 | | | 1117.202 | | gravel | |
| | 52.0 | 1.285 | | | 1117.217 | | cobble | |
| | 53.0 | 1.258 | | | 1117.244 | | gravel | |
| | 54.0 | 1.262 | | | 1117.240 | | gravel | |
| | 55.0 | 1.317 | | | 1117.185 | | gravel | |
| | 56.0 | 1.357 | | | 1117.145 | | sand | |
| | 57.0 | 1.109 | | | 1117.393 | | vegetation | |
| | 58.0 | 0.959 | | | 1117.543 | | vegetation | |
| | 59.0 | 0.852 | | | 1117.650 | | vegetation | bankful height |
| | 60.0 | 0.801 | | | 1117.701 | | vegetation | |
| | 61.0 | 0.826 | | | 1117.676 | | vegetation | |

*TP1 backsight = 0.508 m, height of instrument = 1118.502 m

R5, S1 Differential Level Loop

Differential Levelling Loop - Reach 5, Site 1

Date: 17/09/2001

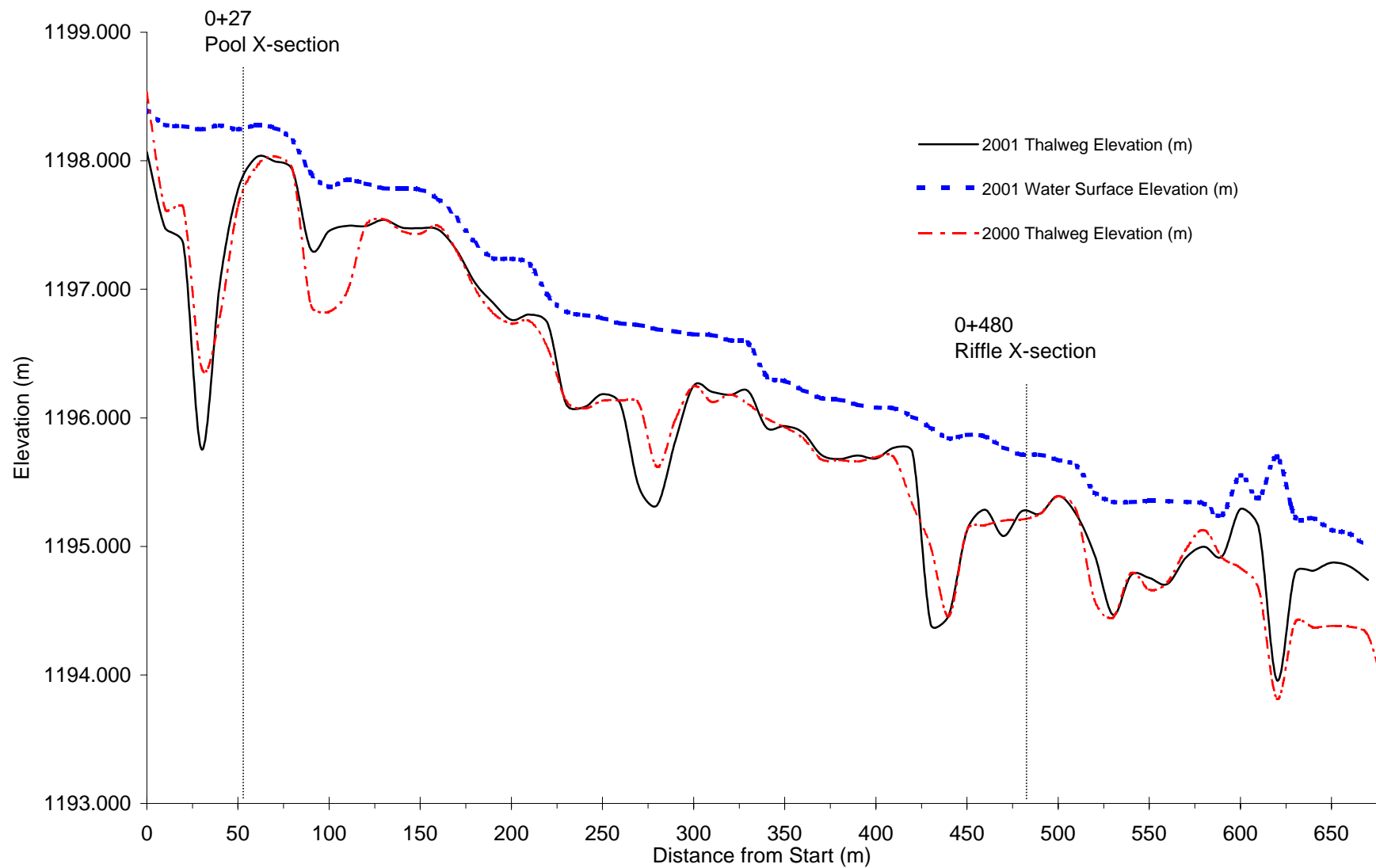
Field (Arbitrary) Elevations (m)

| Station | Backsight | Height of Instrument | Foresight | Elevation |
|---------|-----------|-------------------------|-----------|---------------|
| BM1 | 0.082 | 5.082 | | 5.000 |
| TP1 | 0.708 | 3.699 | 2.091 | 2.991 |
| TP2 | 1.512 | 3.222 | 1.989 | 1.710 |
| TP3 | 1.895 | 3.228 | 1.889 | 1.333 |
| BM2 | | 1.955 | 1.273 | 1.955 |
| BM2 | 1.273 | 3.228 | | 1.955 |
| TP3 | 1.853 | 3.185 | 1.896 | 1.332 |
| TP2 | 1.971 | 3.679 | 1.477 | 1.708 |
| TP1 | 2.081 | 5.078 | 0.682 | 2.997 |
| BM1 | | | 0.077 | 5.001 |
| | | | | error =+0.001 |

True Elevations (m)

| Station | Backsight | Height of Instrument | Foresight | Elevation |
|---------|-----------|-------------------------|-----------|---------------|
| BM1 | 0.082 | 1120.082 | | 1120.000 |
| TP1 | 0.708 | 1118.699 | 2.091 | 1117.991 |
| TP2 | 1.512 | 1118.222 | 1.989 | 1116.710 |
| TP3 | 1.895 | 1118.228 | 1.889 | 1116.333 |
| BM2 | | 1116.955 | 1.273 | 1116.955 |
| BM2 | 1.273 | 1118.228 | | 1116.955 |
| TP3 | 1.853 | 1118.185 | 1.896 | 1116.332 |
| TP2 | 1.971 | 1118.679 | 1.477 | 1116.708 |
| TP1 | 2.081 | 1120.078 | 0.682 | 1117.997 |
| BM1 | | | 0.077 | 1120.001 |
| | | | | error =+0.001 |

| Benchmark Elevations (m) | | |
|--------------------------|----------|----------|
| | 2000 | 2001 |
| BM1 | 1120.000 | 1120.000 |
| BM2 | 1116.894 | 1116.955 |



Longitudinal profile of a representative two meander lengths of the Wigwam River in reach 6, study site 2.

Reach 6, Site 2 Long Survey

Longitudinal Survey

Location: Wigwam River
Reach: 6
Site: 2

UTM: start 653886E, 5441349N
 end 0+670m D/S from start
Crew: KM/LC
Date: 27/09/2001

Benchmark UTM:

BM1 653768E, 5441437N
 BM2 653770E, 5441871N
 BM3 653800E, 5441846N

Benchmark Elevations:

BM1 1200.000 BM2 1195.679
 TP1 1198.379 BM3 1196.180
 TP2 1197.690
 TP3 1196.116

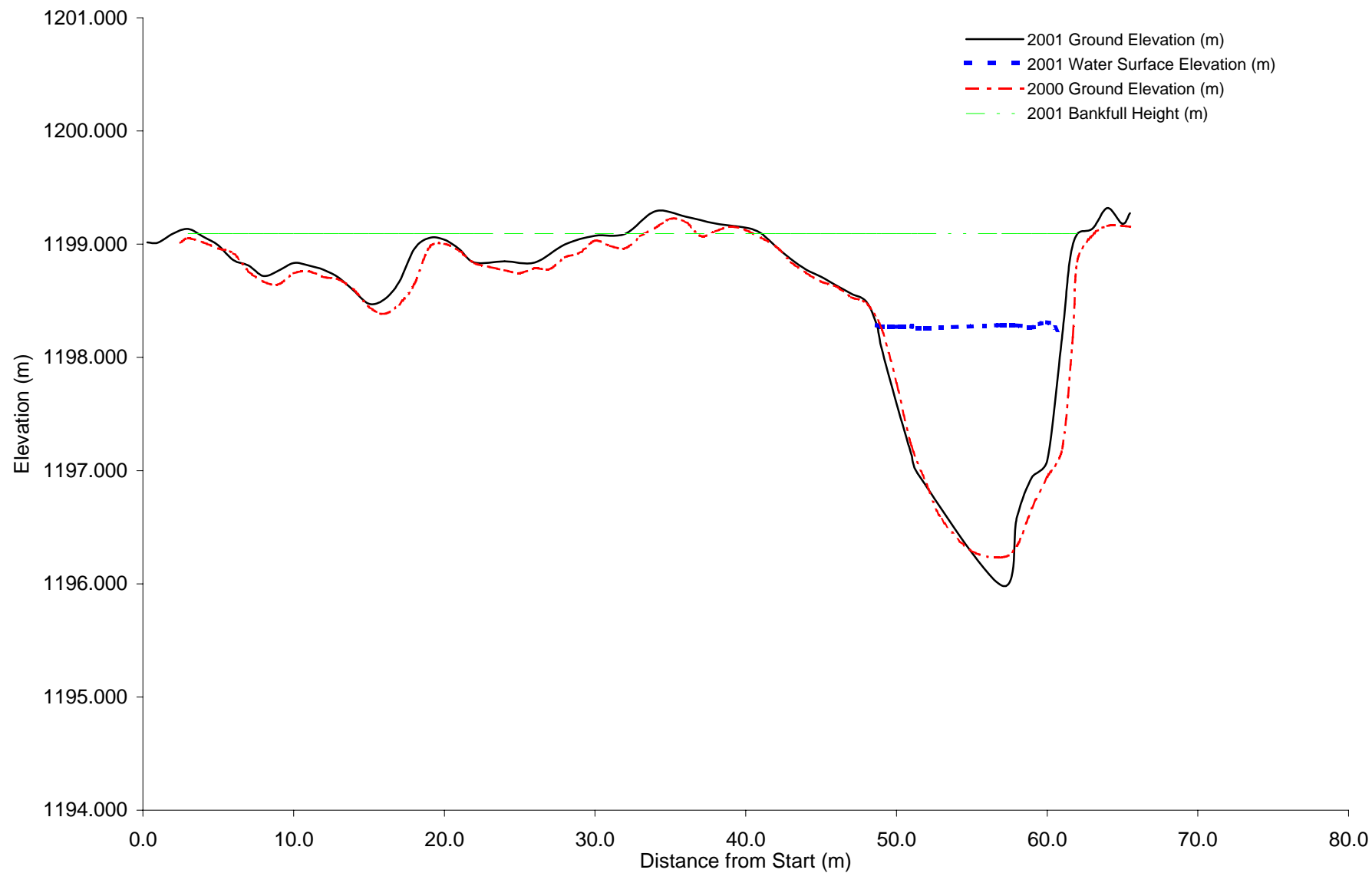
| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | | Dominant Substrate | Habitat Type | Comments |
|--------------------|-------------------------|-----------------------|-----------------|-----------------------------|-----------------------|-----------------------------|--------------------|--------------|----------------------------|
| | | Thalweg Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Thalweg Elevation (m) | Water Surface Elevation (m) | | | |
| BM1 | 0 | 2.671 | 0.33 | 2.341 | 1198.067 | 1198.397 | cobble | riffle | |
| | 10 | 3.263 | 0.805 | 2.458 | 1197.475 | 1198.28 | gravel | pool | back channel |
| | 20 | 3.389 | 0.92 | 2.469 | 1197.349 | 1198.269 | gravel | pool | 3 BT in pool |
| | 30 | 4.984 | 2.49 | 2.494 | 1195.754 | 1198.244 | gravel | pool | deep pool, ~elev. & depth |
| | 40 | 3.694 | 1.23 | 2.464 | 1197.044 | 1198.274 | gravel | pool | 1male BT, no visible redds |
| | 50 | 2.963 | 0.47 | 2.493 | 1197.775 | 1198.245 | gravel | pool | pool tailout |
| | 60 | 2.713 | 0.25 | 2.463 | 1198.025 | 1198.275 | gravel | glide | |
| | 70 | 2.741 | 0.26 | 2.481 | 1197.997 | 1198.257 | cobble | glide | |
| | 80 | 2.812 | 0.23 | 2.582 | 1197.926 | 1198.156 | cobble | pool | LWD scour pool |
| TP1 | 90 | 3.427 | 0.59 | 2.837 | 1197.311 | 1197.901 | gravel | riffle | |
| | 100 | 2.228 | 0.345 | 1.883 | 1197.454 | 1197.799 | cobble | riffle | |
| | 110 | 2.189 | 0.36 | 1.829 | 1197.493 | 1197.853 | cobble | riffle | |
| | 120 | 2.19 | 0.33 | 1.86 | 1197.492 | 1197.822 | cobble | riffle | |
| | 130 | 2.141 | 0.245 | 1.896 | 1197.541 | 1197.786 | cobble | riffle | |
| | 140 | 2.203 | 0.305 | 1.898 | 1197.479 | 1197.784 | gravel | glide | |
| | 150 | 2.206 | 0.3 | 1.906 | 1197.476 | 1197.776 | gravel | glide | |
| | 160 | 2.217 | 0.235 | 1.982 | 1197.465 | 1197.7 | cobble | riffle | joining side channel |
| | 170 | 2.378 | 0.25 | 2.128 | 1197.304 | 1197.554 | cobble | riffle | |
| | 180 | 2.631 | 0.31 | 2.321 | 1197.051 | 1197.361 | cobble | riffle | |
| | 190 | 2.788 | 0.35 | 2.438 | 1196.894 | 1197.244 | cobble | riffle | |
| | 200 | 2.92 | 0.475 | 2.445 | 1196.762 | 1197.237 | cobble | riffle | |
| | 210 | 2.878 | 0.39 | 2.488 | 1196.804 | 1197.194 | cobble | riffle | |
| | 220 | 2.951 | 0.22 | 2.731 | 1196.731 | 1196.951 | cobble | riffle | |
| | 230 | 3.574 | 0.72 | 2.854 | 1196.108 | 1196.828 | gravel | pool | |
| | 240 | 3.598 | 0.715 | 2.883 | 1196.084 | 1196.799 | cobble | glide | |
| | 250 | 3.497 | 0.59 | 2.907 | 1196.185 | 1196.775 | finer | glide | |

Reach 6, Site 2 Long Survey

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | | Dominant Substrate | Habitat Type | Comments |
|-----------------------|----------------------------|--------------------------|--------------------|--------------------------------|--------------------------|--------------------------------|-----------------------|-----------------|--|
| | | Thalweg Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Thalweg Elevation (m) | Water Surface Elevation (m) | | | |
| TP2 | 260 | 3.578 | 0.63 | 2.948 | 1196.104 | 1196.734 | finer | pool | deep pool, LWD jam |
| | 270 | 4.219 | 1.26 | 2.959 | 1195.463 | 1196.723 | finer | pool | |
| | 280 | 3.34 | 1.37 | 1.97 | 1195.320 | 1196.69 | finer | pool | |
| | 290 | 2.839 | 0.85 | 1.989 | 1195.821 | 1196.671 | gravel | pool | |
| | 300 | 2.411 | 0.4 | 2.011 | 1196.249 | 1196.649 | gravel | pool | |
| | 310 | 2.457 | 0.44 | 2.017 | 1196.203 | 1196.643 | cobble | glide | |
| | 320 | 2.482 | 0.425 | 2.057 | 1196.178 | 1196.603 | cobble | glide | |
| | 330 | 2.453 | 0.37 | 2.083 | 1196.207 | 1196.577 | cobble | riffle | |
| | 340 | 2.735 | 0.4 | 2.335 | 1195.925 | 1196.325 | cobble | riffle | |
| | 350 | 2.724 | 0.35 | 2.374 | 1195.936 | 1196.286 | gravel | riffle | |
| | 360 | 2.775 | 0.33 | 2.445 | 1195.885 | 1196.215 | cobble | riffle | |
| | 370 | 2.947 | 0.44 | 2.507 | 1195.713 | 1196.153 | cobble | riffle | |
| | 380 | 2.98 | 0.46 | 2.52 | 1195.680 | 1196.14 | gravel | glide | |
| | 390 | 2.953 | 0.395 | 2.558 | 1195.707 | 1196.102 | gravel | glide | |
| | 400 | 2.976 | 0.395 | 2.581 | 1195.684 | 1196.079 | gravel | glide | |
| TP3 | 410 | 2.892 | 0.305 | 2.587 | 1195.768 | 1196.073 | gravel | glide | 1 BT 3 BT |
| | 420 | 2.927 | 0.275 | 2.652 | 1195.733 | 1196.008 | cobble | riffle | |
| | 430 | 4.266 | 1.53 | 2.736 | 1194.394 | 1195.924 | finer | pool | |
| | 440 | 3.121 | 1.38 | 1.741 | 1194.461 | 1195.841 | gravel | pool | rifle cross section |
| | 450 | 2.461 | 0.745 | 1.716 | 1195.121 | 1195.866 | cobble | glide | |
| | 460 | 2.296 | 0.57 | 1.726 | 1195.286 | 1195.856 | cobble | glide | |
| | 470 | 2.501 | 0.69 | 1.811 | 1195.081 | 1195.771 | cobble | riffle | pool EF site |
| | 480 | 2.308 | 0.44 | 1.868 | 1195.274 | 1195.714 | cobble | riffle | |
| | 490 | 2.329 | 0.46 | 1.869 | 1195.253 | 1195.713 | cobble | riffle | |
| | 500 | 2.19 | 0.28 | 1.91 | 1195.392 | 1195.672 | cobble | riffle | 14 BT 3 BT redds 2 males, 1 female BT |
| | 510 | 2.337 | 0.38 | 1.957 | 1195.245 | 1195.625 | cobble | riffle | |
| | 520 | 2.651 | 0.49 | 2.161 | 1194.931 | 1195.421 | gravel | pool | |
| | 530 | 3.115 | 0.88 | 2.235 | 1194.467 | 1195.347 | gravel | pool | BT in pool LWD pool gravel accum. behind LWD |
| | 540 | 2.807 | 0.57 | 2.237 | 1194.775 | 1195.345 | gravel | pool | |
| | 550 | 2.828 | 0.6 | 2.228 | 1194.754 | 1195.354 | gravel | glide | |
| | 560 | 2.874 | 0.645 | 2.229 | 1194.708 | 1195.353 | gravel | glide | |
| | 570 | 2.671 | 0.435 | 2.236 | 1194.911 | 1195.346 | gravel | glide | |
| | 580 | 2.584 | 0.335 | 2.249 | 1194.998 | 1195.333 | gravel | glide | |
| | 590 | 2.659 | 0.32 | 2.339 | 1194.923 | 1195.243 | cobble | riffle | |
| | 600 | 2.291 | 0.26 | 2.031 | 1195.291 | 1195.551 | cobble | riffle | |
| | 610 | 2.439 | 0.23 | 2.209 | 1195.143 | 1195.373 | gravel | pool | |
| | 620 | 3.624 | 1.74 | 1.884 | 1193.958 | 1195.698 | gravel | pool | |
| | 630 | 2.789 | 0.435 | 2.354 | 1194.793 | 1195.228 | gravel | glide | |

Reach 6, Site 2 Long Survey

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | | Dominant Substrate | Habitat Type | Comments |
|-----------------------|----------------------------|--------------------------|--------------------|--------------------------------|--------------------------|--------------------------------|-----------------------|-----------------|----------|
| | | Thalweg Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Thalweg Elevation (m) | Water Surface Elevation (m) | | | |
| | 640 | 2.771 | 0.41 | 2.361 | 1194.811 | 1195.221 | cobble | riffle | |
| | 650 | 2.709 | 0.255 | 2.454 | 1194.873 | 1195.128 | cobble | riffle | |
| | 660 | 2.739 | 0.255 | 2.484 | 1194.843 | 1195.098 | cobble | riffle | |
| | 670 | 2.842 | 0.25 | 2.592 | 1194.740 | 1194.99 | cobble | riffle | |
| | 680 | 3.232 | 0.25 | 2.982 | 1194.350 | 1194.6 | cobble | riffle | |



Cross sectional profile of a representative pool habitat unit of the Wigwam River in reach 6, study site 2.

Reach 6, Site 2 Long Survey

Longitudinal Survey

Location: Wigwam River

Reach: 6

Site: 2

UTM: start 653886E, 5441349N

end 0+670m D/S from start

Crew: KM/LC

Date: 27/09/2001

Benchmark UTM:

BM1 653768E, 5441437N

BM2 653770E, 5441871N

BM3 653800E, 5441846N

Benchmark Elevations:

BM1 1200.000

BM2 1195.679

TP1 1198.379

BM3 1196.180

TP2 1197.690

TP3 1196.116

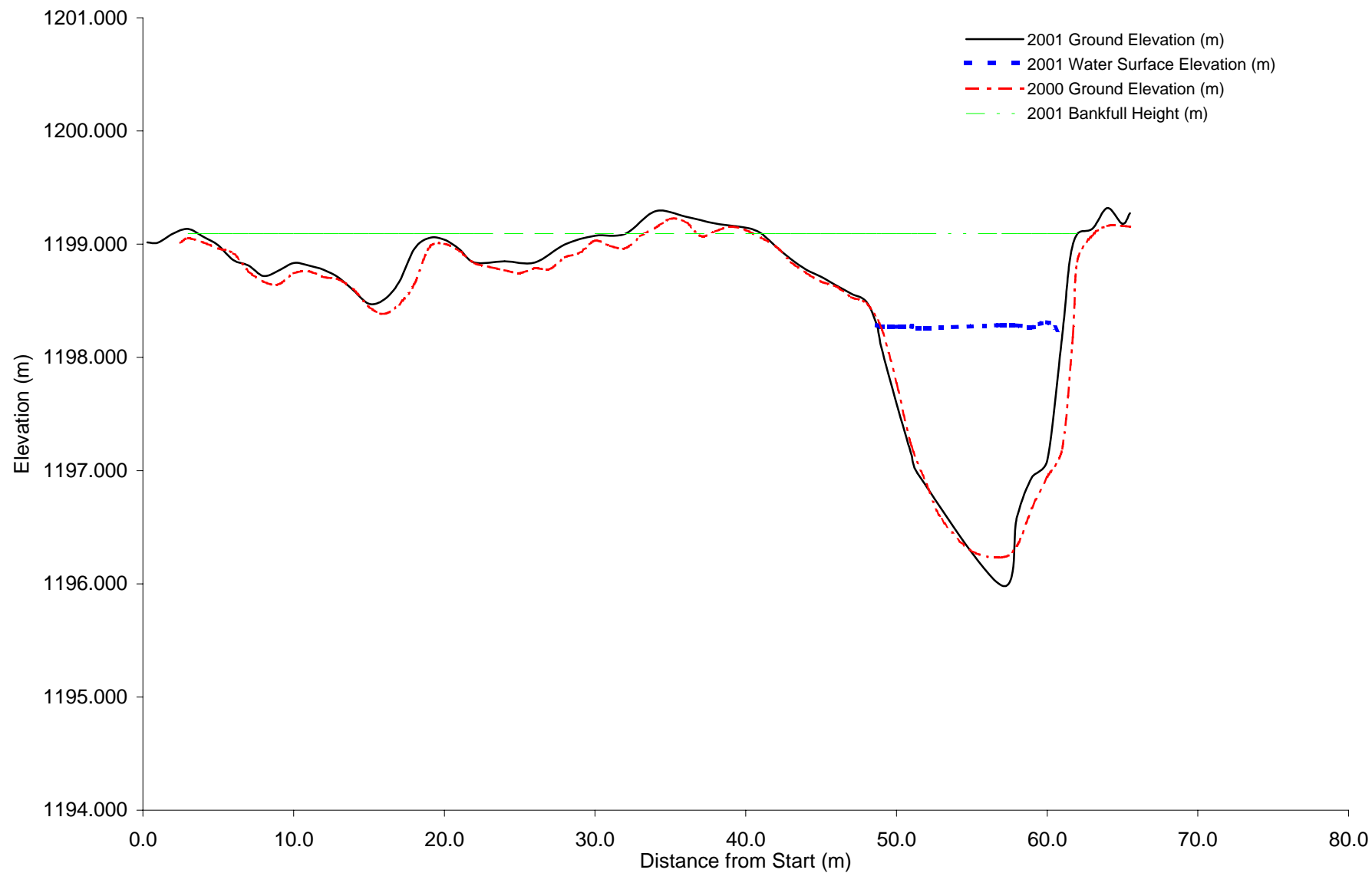
| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | | Dominant Substrate | Habitat Type | Comments |
|-----------------------|----------------------------|--------------------------|--------------------|--------------------------------|--------------------------|--------------------------------|-----------------------|-----------------|----------------------------|
| | | Thalweg Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Thalweg Elevation (m) | Water Surface Elevation (m) | | | |
| BM1 | 0 | 2.671 | 0.33 | 2.341 | 1198.067 | 1198.397 | cobble | riffle | |
| | 10 | 3.263 | 0.805 | 2.458 | 1197.475 | 1198.28 | gravel | pool | back channel |
| | 20 | 3.389 | 0.92 | 2.469 | 1197.349 | 1198.269 | gravel | pool | 3 BT in pool |
| | 30 | 4.984 | 2.49 | 2.494 | 1195.754 | 1198.244 | gravel | pool | deep pool, ~elev. & depth |
| | 40 | 3.694 | 1.23 | 2.464 | 1197.044 | 1198.274 | gravel | pool | 1male BT, no visible redds |
| | 50 | 2.963 | 0.47 | 2.493 | 1197.775 | 1198.245 | gravel | pool | pool tailout |
| | 60 | 2.713 | 0.25 | 2.463 | 1198.025 | 1198.275 | gravel | glide | |
| | 70 | 2.741 | 0.26 | 2.481 | 1197.997 | 1198.257 | cobble | glide | |
| | 80 | 2.812 | 0.23 | 2.582 | 1197.926 | 1198.156 | cobble | pool | LWD scour pool |
| TP1 | 90 | 3.427 | 0.59 | 2.837 | 1197.311 | 1197.901 | gravel | riffle | |
| | 100 | 2.228 | 0.345 | 1.883 | 1197.454 | 1197.799 | cobble | riffle | |
| | 110 | 2.189 | 0.36 | 1.829 | 1197.493 | 1197.853 | cobble | riffle | |
| | 120 | 2.19 | 0.33 | 1.86 | 1197.492 | 1197.822 | cobble | riffle | |
| | 130 | 2.141 | 0.245 | 1.896 | 1197.541 | 1197.786 | cobble | riffle | |
| | 140 | 2.203 | 0.305 | 1.898 | 1197.479 | 1197.784 | gravel | glide | |
| | 150 | 2.206 | 0.3 | 1.906 | 1197.476 | 1197.776 | gravel | glide | |
| | 160 | 2.217 | 0.235 | 1.982 | 1197.465 | 1197.7 | cobble | riffle | joining side channel |
| | 170 | 2.378 | 0.25 | 2.128 | 1197.304 | 1197.554 | cobble | riffle | |
| | 180 | 2.631 | 0.31 | 2.321 | 1197.051 | 1197.361 | cobble | riffle | |
| | 190 | 2.788 | 0.35 | 2.438 | 1196.894 | 1197.244 | cobble | riffle | |
| | 200 | 2.92 | 0.475 | 2.445 | 1196.762 | 1197.237 | cobble | riffle | |
| | 210 | 2.878 | 0.39 | 2.488 | 1196.804 | 1197.194 | cobble | riffle | |
| | 220 | 2.951 | 0.22 | 2.731 | 1196.731 | 1196.951 | cobble | riffle | |
| | 230 | 3.574 | 0.72 | 2.854 | 1196.108 | 1196.828 | gravel | pool | |
| | 240 | 3.598 | 0.715 | 2.883 | 1196.084 | 1196.799 | cobble | glide | |
| | 250 | 3.497 | 0.59 | 2.907 | 1196.185 | 1196.775 | finer | glide | |

Reach 6, Site 2 Long Survey

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | | Dominant Substrate | Habitat Type | Comments |
|-----------------------|----------------------------|--------------------------|--------------------|--------------------------------|--------------------------|--------------------------------|-----------------------|-----------------|--------------------------|
| | | Thalweg Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Thalweg Elevation (m) | Water Surface Elevation (m) | | | |
| TP2 | 260 | 3.578 | 0.63 | 2.948 | 1196.104 | 1196.734 | finer | pool | deep pool, LWD jam |
| | 270 | 4.219 | 1.26 | 2.959 | 1195.463 | 1196.723 | finer | pool | |
| | 280 | 3.34 | 1.37 | 1.97 | 1195.320 | 1196.69 | finer | pool | |
| | 290 | 2.839 | 0.85 | 1.989 | 1195.821 | 1196.671 | gravel | pool | |
| | 300 | 2.411 | 0.4 | 2.011 | 1196.249 | 1196.649 | gravel | pool | |
| | 310 | 2.457 | 0.44 | 2.017 | 1196.203 | 1196.643 | cobble | glide | |
| | 320 | 2.482 | 0.425 | 2.057 | 1196.178 | 1196.603 | cobble | glide | |
| | 330 | 2.453 | 0.37 | 2.083 | 1196.207 | 1196.577 | cobble | riffle | |
| | 340 | 2.735 | 0.4 | 2.335 | 1195.925 | 1196.325 | cobble | riffle | |
| | 350 | 2.724 | 0.35 | 2.374 | 1195.936 | 1196.286 | gravel | riffle | |
| | 360 | 2.775 | 0.33 | 2.445 | 1195.885 | 1196.215 | cobble | riffle | |
| | 370 | 2.947 | 0.44 | 2.507 | 1195.713 | 1196.153 | cobble | riffle | |
| | 380 | 2.98 | 0.46 | 2.52 | 1195.680 | 1196.14 | gravel | glide | |
| | 390 | 2.953 | 0.395 | 2.558 | 1195.707 | 1196.102 | gravel | glide | |
| | 400 | 2.976 | 0.395 | 2.581 | 1195.684 | 1196.079 | gravel | glide | |
| TP3 | 410 | 2.892 | 0.305 | 2.587 | 1195.768 | 1196.073 | gravel | glide | |
| | 420 | 2.927 | 0.275 | 2.652 | 1195.733 | 1196.008 | cobble | riffle | |
| | 430 | 4.266 | 1.53 | 2.736 | 1194.394 | 1195.924 | finer | pool | 1 BT |
| | 440 | 3.121 | 1.38 | 1.741 | 1194.461 | 1195.841 | gravel | pool | 3 BT |
| | 450 | 2.461 | 0.745 | 1.716 | 1195.121 | 1195.866 | cobble | glide | |
| | 460 | 2.296 | 0.57 | 1.726 | 1195.286 | 1195.856 | cobble | glide | |
| | 470 | 2.501 | 0.69 | 1.811 | 1195.081 | 1195.771 | cobble | riffle | |
| | 480 | 2.308 | 0.44 | 1.868 | 1195.274 | 1195.714 | cobble | riffle | |
| | 490 | 2.329 | 0.46 | 1.869 | 1195.253 | 1195.713 | cobble | riffle | |
| | 500 | 2.19 | 0.28 | 1.91 | 1195.392 | 1195.672 | cobble | riffle | riffle cross section |
| | 510 | 2.337 | 0.38 | 1.957 | 1195.245 | 1195.625 | cobble | riffle | |
| | 520 | 2.651 | 0.49 | 2.161 | 1194.931 | 1195.421 | gravel | pool | |
| | 530 | 3.115 | 0.88 | 2.235 | 1194.467 | 1195.347 | gravel | pool | pool EF site |
| | 540 | 2.807 | 0.57 | 2.237 | 1194.775 | 1195.345 | gravel | pool | |
| | 550 | 2.828 | 0.6 | 2.228 | 1194.754 | 1195.354 | gravel | glide | |
| | 560 | 2.874 | 0.645 | 2.229 | 1194.708 | 1195.353 | gravel | glide | 14 BT |
| | 570 | 2.671 | 0.435 | 2.236 | 1194.911 | 1195.346 | gravel | glide | 3 BT redds |
| | 580 | 2.584 | 0.335 | 2.249 | 1194.998 | 1195.333 | gravel | glide | 2 males, 1 female BT |
| | 590 | 2.659 | 0.32 | 2.339 | 1194.923 | 1195.243 | cobble | riffle | |
| | 600 | 2.291 | 0.26 | 2.031 | 1195.291 | 1195.551 | cobble | riffle | |
| | 610 | 2.439 | 0.23 | 2.209 | 1195.143 | 1195.373 | gravel | pool | BT in pool |
| | 620 | 3.624 | 1.74 | 1.884 | 1193.958 | 1195.698 | gravel | pool | LWD pool |
| | 630 | 2.789 | 0.435 | 2.354 | 1194.793 | 1195.228 | gravel | glide | gravel accum. behind LWD |

Reach 6, Site 2 Long Survey

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | | Dominant Substrate | Habitat Type | Comments |
|-----------------------|----------------------------|--------------------------|--------------------|--------------------------------|--------------------------|--------------------------------|-----------------------|-----------------|----------|
| | | Thalweg Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Thalweg Elevation (m) | Water Surface Elevation (m) | | | |
| | 640 | 2.771 | 0.41 | 2.361 | 1194.811 | 1195.221 | cobble | riffle | |
| | 650 | 2.709 | 0.255 | 2.454 | 1194.873 | 1195.128 | cobble | riffle | |
| | 660 | 2.739 | 0.255 | 2.484 | 1194.843 | 1195.098 | cobble | riffle | |
| | 670 | 2.842 | 0.25 | 2.592 | 1194.740 | 1194.99 | cobble | riffle | |
| | 680 | 3.232 | 0.25 | 2.982 | 1194.350 | 1194.6 | cobble | riffle | |



Cross sectional profile of a representative pool habitat unit of the Wigwam River in reach 6, study site 2.

Reach 6, Site 2 Pool X-Sxn

Pool Cross Sectional Survey

Location: Wigwam River

Reach: 6

Site: 2

UTM: 653836E, 5441375N

Crew: SC/KM

Date: 28/09/2001

Benchmark Elevations:

BM1 1200.000

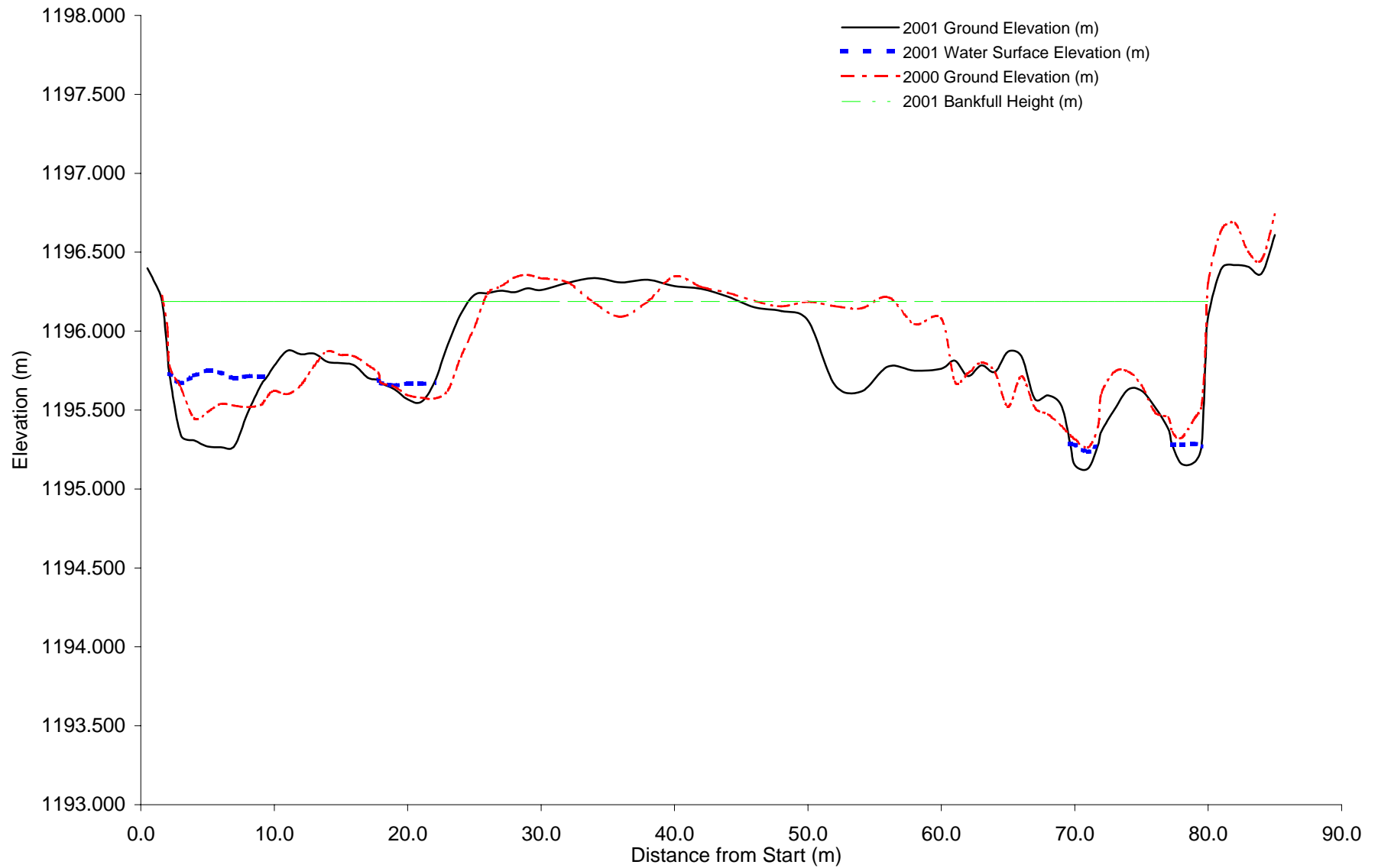
pool cross section located at 0+27m of longitudinal profile

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | Dominant Substrate | Comments |
|-----------------------|----------------------------|-------------------------|--------------------|--------------------------------|-------------------------|-----------------------|----------------------|
| | | Ground Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | | |
| BM1* | 0.3 | 1.696 | | | 1199.016 | vegetation | RUB start |
| | 1.0 | 1.698 | | | 1199.014 | | |
| | 2.0 | 1.618 | | | 1199.094 | | |
| | 3.0 | 1.577 | | | 1199.135 | | bankfull |
| | 4.0 | 1.647 | | | 1199.065 | | |
| | 5.0 | 1.723 | | | 1198.989 | | |
| | 6.0 | 1.852 | | | 1198.860 | gravel | |
| | 7.0 | 1.901 | | | 1198.811 | gravel | |
| | 8.0 | 1.994 | | | 1198.718 | gravel | |
| | 9.0 | 1.945 | | | 1198.767 | gravel | |
| | 10.0 | 1.878 | | | 1198.834 | gravel | |
| | 11.0 | 1.899 | | | 1198.813 | gravel | |
| | 12.0 | 1.938 | | | 1198.774 | gravel | |
| | 13.0 | 2.009 | | | 1198.703 | gravel | |
| | 14.0 | 2.123 | | | 1198.589 | gravel | |
| | 15.0 | 2.238 | | | 1198.474 | gravel | |
| | 16.0 | 2.201 | | | 1198.511 | gravel | |
| | 17.0 | 2.047 | | | 1198.665 | gravel | |
| | 18.0 | 1.755 | | | 1198.957 | gravel | vegetated gravel bar |
| | 19.0 | 1.658 | | | 1199.054 | gravel | |
| | 20.0 | 1.672 | | | 1199.040 | gravel | |
| | 21.0 | 1.756 | | | 1198.956 | gravel | |
| | 22.0 | 1.873 | | | 1198.839 | gravel | |
| | 24.0 | 1.863 | | | 1198.849 | gravel | |
| | 26.0 | 1.875 | | | 1198.837 | gravel | |
| | 28.0 | 1.713 | | | 1198.999 | gravel | |
| | 30.0 | 1.638 | | | 1199.074 | gravel | |
| | 32.0 | 1.620 | | | 1199.092 | gravel | |
| | 34.0 | 1.421 | | | 1199.291 | gravel | |
| | 36.0 | 1.468 | | | 1199.244 | gravel | |
| | 38.0 | 1.530 | | | 1199.182 | sand | |

Reach 6, Site 2 Pool X-Sxn

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | Dominant Substrate | Comments |
|-----------------------|----------------------------|-------------------------|--------------------|--------------------------------|-------------------------|--------------------------------|---------------------------------|
| | | Ground Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | Water Surface Elevation (m) | |
| | 40.0 | 1.566 | | | 1199.146 | | sand |
| | 41.0 | 1.613 | | | 1199.099 | | gravel bankfull height |
| | 42.0 | 1.733 | | | 1198.979 | | sand |
| | 43.0 | 1.843 | | | 1198.869 | | sand |
| | 44.0 | 1.937 | | | 1198.775 | | gravel |
| | 45.0 | 1.999 | | | 1198.713 | | cobble |
| | 46.0 | 2.076 | | | 1198.636 | | cobble |
| | 47.0 | 2.150 | | | 1198.562 | | gravel |
| | 48.0 | 2.218 | | | 1198.494 | | gravel |
| | 48.7 | 2.428 | 0.000 | 2.428 | 1198.284 | 1198.284 | gravel wetted edge |
| | 49.0 | 2.619 | 0.180 | 2.439 | 1198.093 | 1198.273 | sand |
| | 50.0 | 3.118 | 0.675 | 2.443 | 1197.594 | 1198.269 | cobble 3 redds in pool tail out |
| | 51.0 | 3.572 | 1.135 | 2.437 | 1197.140 | 1198.275 | cobble |
| | 51.4 | 3.736 | 1.280 | 2.456 | 1196.976 | 1198.256 | cobble at least 9 BT in pool |
| | 57.0 | 4.728 | 2.300 | 2.428 | 1195.984 | 1198.284 | finer |
| | 58.0 | 4.119 | 1.690 | 2.429 | 1196.593 | 1198.283 | gravel |
| | 59.0 | 3.769 | 1.320 | 2.449 | 1196.943 | 1198.263 | gravel |
| | 60.0 | 3.621 | 1.220 | 2.401 | 1197.091 | 1198.311 | cobble |
| | 61.0 | 2.516 | 0.000 | 2.516 | 1198.196 | 1198.196 | wetted edge |
| | 61.5 | 1.853 | | | 1198.859 | | vegetation |
| | 62.0 | 1.623 | | | 1199.089 | | vegetation bankfull |
| | 63.0 | 1.574 | | | 1199.138 | | vegetation |
| | 64.0 | 1.392 | | | 1199.320 | | vegetation |
| | 65.0 | 1.532 | | | 1199.180 | | vegetation |
| | 65.5 | 1.439 | | | 1199.273 | | vegetation LUB |

* BM1 backsight = 0.712 m, height of instrument = 1200.712 m



Cross sectional profile of a representative riffle habitat unit of the Wigwam River in reach 6, study site 2.

Reach 6, Site 2 Riffle X-Sxn

Riffle Cross Sectional Survey

Location: Wigwam River

Reach: 6

Site: 2

UTM: 653836E, 5441375N

Crew: KM/LC

Date: 27/09/2001

Benchmark Elevation

BM3

riffle cross section located at 0+ 480 m of longitudinal profile

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | Dominant Substrate | Comments |
|-----------------------|----------------------------|------------------|--------------------|--------------------------------|-------------------------|-----------------------|-----------------|
| | | Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | | |
| BM3* | 0.5 | 1.441 | | | 1196.398 | vegetation | start RUB bank |
| | 1.0 | 1.526 | | | 1196.313 | | |
| | 1.6 | 1.651 | | | 1196.188 | | bankfull height |
| | 2.0 | 1.973 | | | 1195.866 | finer | |
| | 2.2 | 2.109 | 0 | 2.109 | 1195.730 | gravel | RUB wetted edge |
| | 3.0 | 2.499 | 0.33 | 2.169 | 1195.340 | cobble | |
| | 4.0 | 2.531 | 0.41 | 2.121 | 1195.308 | cobble | |
| | 5.0 | 2.57 | 0.48 | 2.09 | 1195.269 | cobble | |
| | 6.0 | 2.574 | 0.47 | 2.104 | 1195.265 | cobble | |
| | 7.0 | 2.568 | 0.43 | 2.138 | 1195.271 | cobble | |
| | 8.0 | 2.36 | 0.235 | 2.125 | 1195.479 | cobble | |
| | 9.0 | 2.181 | 0.055 | 2.126 | 1195.658 | cobble | |
| | 9.5 | 2.129 | 0 | 2.129 | 1195.710 | gravel | wetted edge |
| | 10.0 | 2.057 | | | 1195.782 | cobble | |
| | 11.0 | 1.963 | | | 1195.876 | cobble | mid channel bar |
| | 12.0 | 1.986 | | | 1195.853 | cobble | |
| | 13.0 | 1.981 | | | 1195.858 | cobble | |
| | 14.0 | 2.034 | | | 1195.805 | cobble | |
| | 15.0 | 2.041 | | | 1195.798 | cobble | |
| | 16.0 | 2.055 | | | 1195.784 | cobble | |
| | 17.0 | 2.133 | | | 1195.706 | cobble | |
| | 17.8 | 2.148 | 0 | 2.148 | 1195.691 | gravel | wetted edge |
| | 18.0 | 2.168 | 0 | 2.168 | 1195.671 | gravel | |
| | 19.0 | 2.207 | 0.025 | 2.182 | 1195.632 | gravel | |
| | 20.0 | 2.271 | 0.1 | 2.171 | 1195.568 | cobble | |
| | 21.0 | 2.288 | 0.115 | 2.173 | 1195.551 | gravel | |
| | 22.0 | 2.165 | 0 | 2.165 | 1195.674 | cobble | wetted edge |
| | 23.0 | 1.926 | | | 1195.913 | cobble | |
| | 24.0 | 1.729 | | | 1196.110 | cobble | |
| | 25.0 | 1.609 | | | 1196.230 | gravel | |
| | 26.0 | 1.598 | | | 1196.241 | gravel | |

Reach 6, Site 2 Riffle X-Sxn

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | Dominant Substrate | Comments |
|-----------------------|----------------------------|------------------|--------------------|--------------------------------|-------------------------|--------------------------------|---------------------------------|
| | | Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | Water Surface Elevation (m) | |
| | 27.0 | 1.583 | | | 1196.256 | | gravel |
| | 28.0 | 1.593 | | | 1196.246 | | gravel |
| | 29.0 | 1.567 | | | 1196.272 | | gravel |
| | 30.0 | 1.579 | | | 1196.260 | | gravel |
| | 32.0 | 1.533 | | | 1196.306 | | gravel |
| | 34.0 | 1.502 | | | 1196.337 | | gravel |
| | 36.0 | 1.531 | | | 1196.308 | | gravel |
| | 38.0 | 1.513 | | | 1196.326 | | gravel |
| | 40.0 | 1.554 | | | 1196.285 | | gravel |
| | 42.0 | 1.571 | | | 1196.268 | | gravel |
| | 44.0 | 1.62 | | | 1196.219 | | gravel |
| | 46.0 | 1.688 | | | 1196.151 | | gravel |
| | 48.0 | 1.711 | | | 1196.128 | | gravel |
| | 50.0 | 1.772 | | | 1196.067 | | gravel |
| | 52.0 | 2.178 | | | 1195.661 | | gravel |
| | 54.0 | 2.221 | | | 1195.618 | | gravel |
| | 56.0 | 2.063 | | | 1195.776 | | gravel |
| | 58.0 | 2.089 | | | 1195.750 | | gravel |
| | 60.0 | 2.078 | | | 1195.761 | | cobble |
| | 61.0 | 2.026 | | | 1195.813 | | cobble |
| | 62.0 | 2.123 | | | 1195.716 | | cobble |
| | 63.0 | 2.056 | | | 1195.783 | | cobble |
| | 64.0 | 2.098 | | | 1195.741 | | gravel |
| | 65.0 | 1.969 | | | 1195.870 | | gravel |
| | 66.0 | 1.999 | | | 1195.840 | | gravel |
| | 67.0 | 2.268 | | | 1195.571 | | gravel |
| | 68.0 | 2.246 | | | 1195.593 | | gravel |
| | 69.0 | 2.311 | | | 1195.528 | | gravel |
| | 69.7 | 2.551 | 0 | 2.551 | 1195.288 | 1195.288 | gravel wetted edge |
| | 70.0 | 2.687 | 0.13 | 2.557 | 1195.152 | 1195.282 | gravel |
| | 71.0 | 2.709 | 0.105 | 2.604 | 1195.130 | 1195.235 | gravel |
| | 71.8 | 2.561 | 0 | 2.561 | 1195.278 | 1195.278 | gravel wetted edge |
| | 72.0 | 2.474 | | | 1195.365 | | gravel |
| | 73.0 | 2.331 | | | 1195.508 | | gravel |
| | 74.0 | 2.209 | | | 1195.630 | | gravel |
| | 75.0 | 2.217 | | | 1195.622 | | gravel |
| | 76.0 | 2.319 | | | 1195.520 | | gravel |
| | 77.0 | 2.459 | | | 1195.380 | | gravel |
| | 77.3 | 2.559 | 0 | 2.559 | 1195.280 | 1195.280 | gravel side channel wetted edge |

Reach 6, Site 2 Riffle X-Sxn

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | Dominant Substrate | Comments |
|-----------------------|----------------------------|------------------|--------------------|--------------------------------|-------------------------|--------------------------------|------------|
| | | Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | Water Surface Elevation (m) | |
| | 78.0 | 2.679 | 0.12 | 2.559 | 1195.160 | 1195.280 | gravel |
| | 79.0 | 2.667 | 0.115 | 2.552 | 1195.172 | 1195.287 | gravel |
| | 79.5 | 2.57 | 0 | 2.57 | 1195.269 | 1195.269 | gravel |
| | 79.8 | 2.008 | | | 1195.831 | | finer |
| | 80.0 | 1.748 | | | 1196.091 | | vegetation |
| | 81.0 | 1.442 | | | 1196.397 | | vegetation |
| | 82.0 | 1.421 | | | 1196.418 | | vegetation |
| | 83.0 | 1.432 | | | 1196.407 | | vegetation |
| | 84.0 | 1.473 | | | 1196.366 | | vegetation |
| | 85.0 | 1.23 | | | 1196.609 | | vegetation |

* BM3 backsight = 1.659 m, height of instrument = 1197.839 m

R6,S2 Differential Level Loop

Differential Levelling Loop - Reach 6, Site 2

Date: 24/09/2001

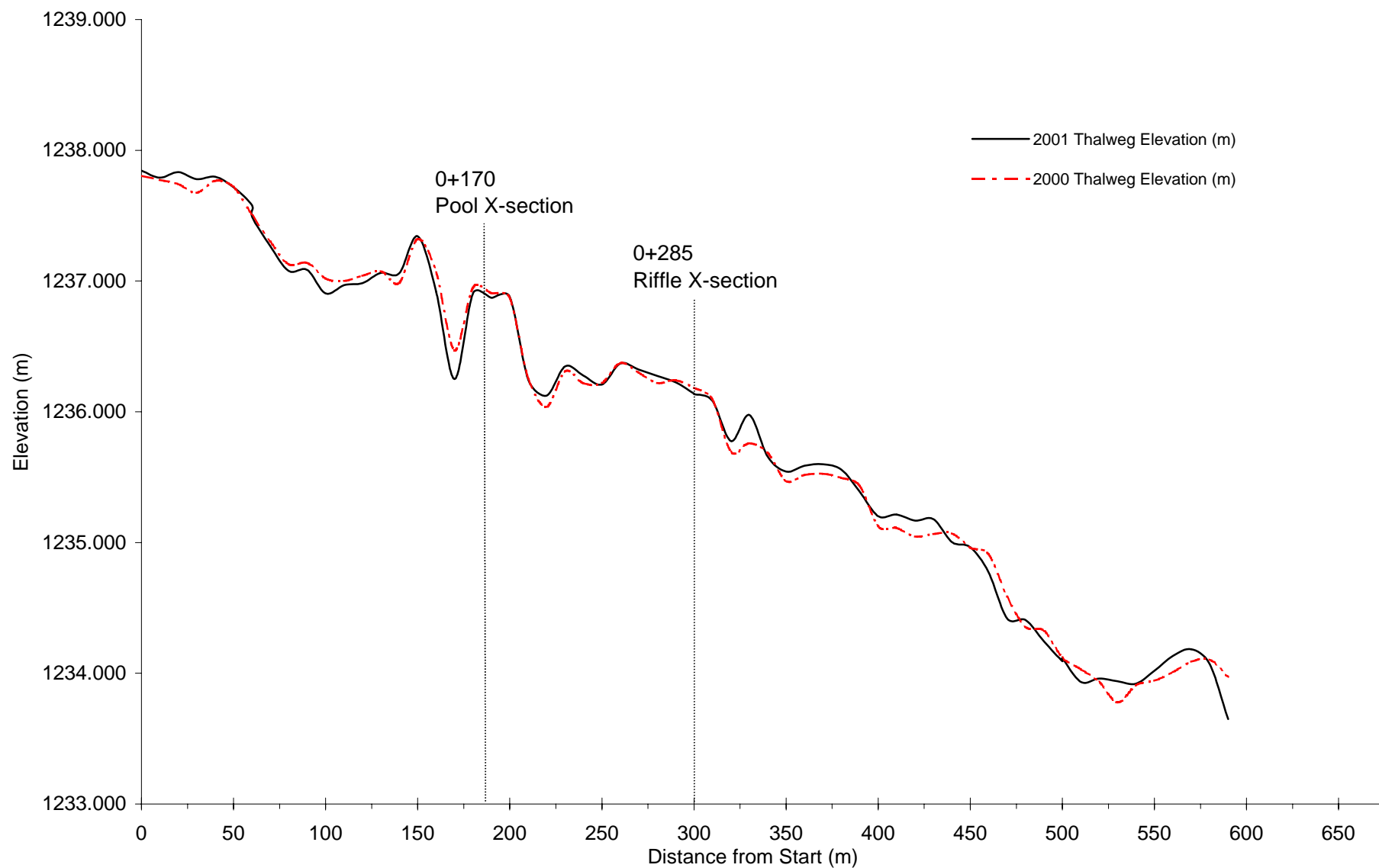
Field (Arbitrary) Elevations (m)

| Station | Backsight | Height of Instrument | Foresight | Elevation |
|---------|-----------|-------------------------|-----------|---------------|
| BM1 | 0.738 | 5.738 | | 5.000 |
| TP1 | 1.306 | 4.682 | 2.362 | 3.376 |
| TP2 | 0.971 | 3.660 | 1.993 | 2.689 |
| TP3 | 1.468 | 2.582 | 2.546 | 1.114 |
| BM3 | 0.977 | 2.157 | 1.402 | 1.180 |
| BM2 | | 0.679 | 1.478 | 0.679 |
| BM2 | 1.478 | 2.157 | | 0.679 |
| BM3 | 1.423 | 2.603 | 0.977 | 1.180 |
| TP3 | 2.549 | 3.667 | 1.485 | 1.118 |
| TP2 | 2.214 | 4.904 | 0.977 | 2.690 |
| TP1 | 2.402 | 5.784 | 1.522 | 3.382 |
| BM1 | | | 0.781 | 5.003 |
| | | | | error= +0.003 |

True Elevations (m)

| Station | Backsight | Height of Instrument | Foresight | Elevation |
|---------|-----------|-------------------------|-----------|---------------|
| BM1 | 0.738 | 1200.738 | | 1200.000 |
| TP1 | 1.306 | 1199.682 | 2.362 | 1198.376 |
| TP2 | 0.971 | 1198.660 | 1.993 | 1197.689 |
| TP3 | 1.468 | 1197.582 | 2.546 | 1196.114 |
| BM3 | 0.977 | 1197.157 | 1.402 | 1196.180 |
| BM2 | | 1195.679 | 1.478 | 1195.679 |
| BM2 | 1.478 | 1197.157 | | 1195.679 |
| BM3 | 1.423 | 1197.603 | 0.977 | 1196.180 |
| TP3 | 2.549 | 1198.667 | 1.485 | 1196.118 |
| TP2 | 2.214 | 1199.904 | 0.977 | 1197.690 |
| TP1 | 2.402 | 1200.784 | 1.522 | 1198.382 |
| BM1 | | | 0.781 | 1200.003 |
| | | | | error= +0.003 |

| Benchmark Elevations (m) | | |
|--------------------------|----------|----------|
| | 2000 | 2001 |
| BM1 | 1200.000 | 1200.000 |
| BM2 | 1195.617 | 1195.679 |
| BM3 | 1196.140 | 1196.180 |



Longitudinal profile of a representative two meander lengths of the Wigwam River in reach 7, study site 3.
Channel was dry at time of survey

Reach 7, Site 3 Long Survey

Longitudinal Survey

Location: Wigwam River

Reach: 7

Site: 3

UTM: start 655471E, 5438625N

end 654977E, 5439074N

Crew: KM/LC

Date: 25/09/2001

Benchmark UTM:

BM1: 655348E, 5438656N

BM2: 655016E, 5439078N

Benchmark Elevations:

BM1: 1240.000

TP4: 1235.732

TP1: 1237.545

BM2: 1237.721

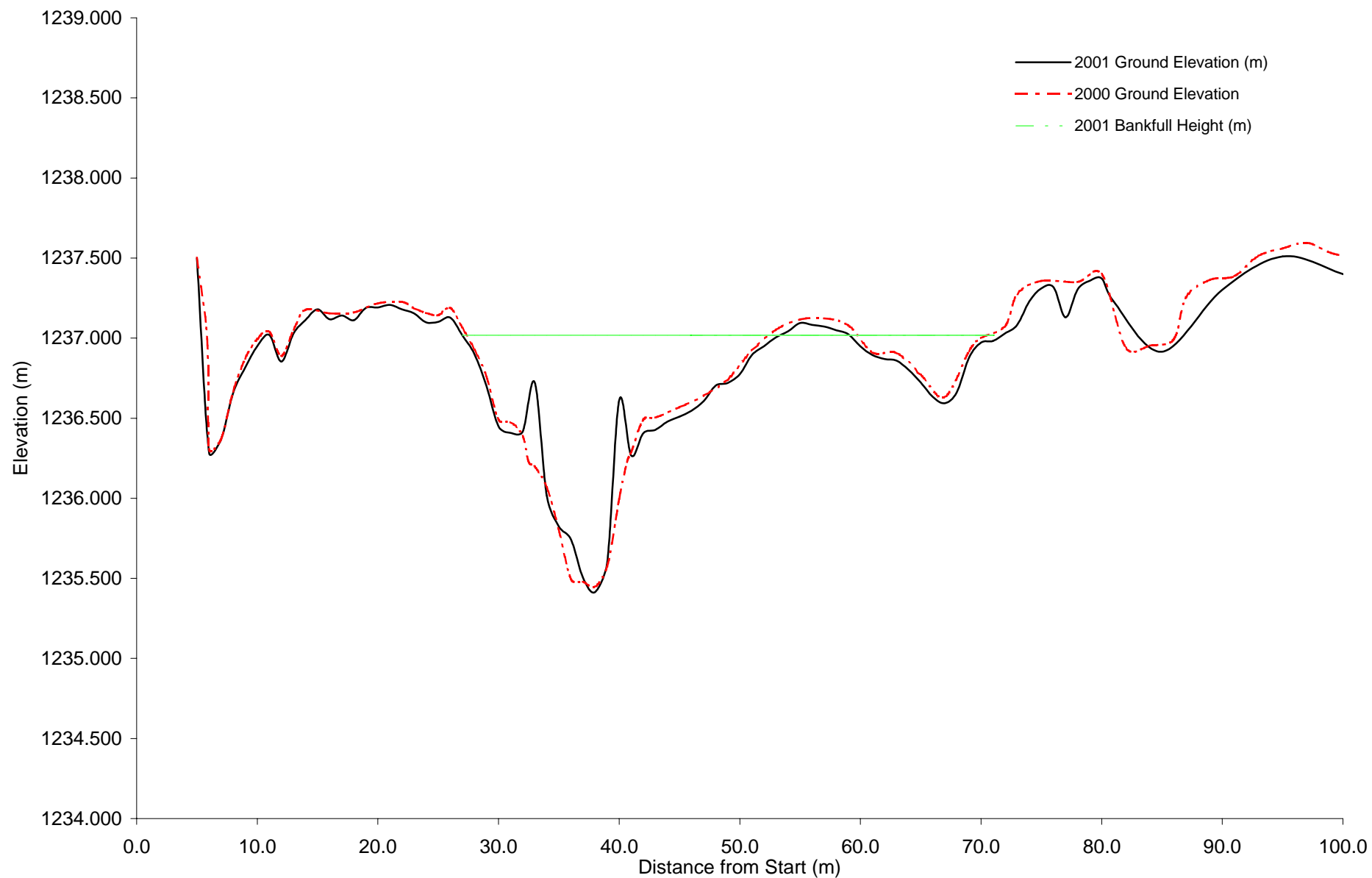
TP2: 1236.601

TP3: 1236.113

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | Dominant Substrate | Habitat Type | Comments |
|-----------------------|----------------------------|--------------------------|----------------------|--------------------------------|--------------------------|--------------------------------|-----------------|----------------|
| | | Thalweg Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Thalweg Elevation (m) | Water Surface Elevation (m) | | |
| BM1 | 0 | 2.665 | channel is dry | | 1237.844 | | cobble | channel is dry |
| | 10 | 2.719 | | | 1237.790 | | cobble | ~habitat types |
| | 20 | 2.676 | | | 1237.833 | | cobble | approximated |
| | 30 | 2.730 | | | 1237.779 | | cobble | from 2000 data |
| | 40 | 2.711 | | | 1237.798 | | cobble | |
| | 50 | 2.791 | | | 1237.718 | | cobble | |
| TP1 | 60 | 2.929 | | | 1237.580 | | cobble | |
| | 60 | 2.309 | | | 1237.491 | | cobble | |
| | 70 | 2.534 | | | 1237.266 | | gravel | |
| | 80 | 2.723 | | | 1237.077 | | gravel | |
| | 90 | 2.715 | | | 1237.085 | | gravel | |
| | 100 | 2.895 | | | 1236.905 | | cobble | glide |
| | 110 | 2.832 | | | 1236.968 | | cobble | glide |
| | 120 | 2.817 | | | 1236.983 | | cobble | glide |
| | 130 | 2.737 | | | 1237.063 | | cobble | glide |
| | 140 | 2.739 | | | 1237.061 | | cobble | glide |
| TP2 | 150 | 2.457 | | | 1237.343 | | gravel | riffle |
| | 160 | 2.883 | | | 1236.917 | | gravel | pool |
| | 170 | 3.550 | | | 1236.250 | | gravel | pool |
| | 180 | 2.892 | | | 1236.908 | | gravel | riffle |
| | 190 | 2.929 | | | 1236.871 | | gravel | riffle |
| | 200 | 2.921 | | | 1236.879 | | gravel | pool |
| | 210 | 2.870 | | | 1236.245 | | gravel | pool |
| | 220 | 2.991 | | | 1236.124 | | boulder | glide |
| | 230 | 2.768 | | | 1236.347 | | boulder | glide |
| | 240 | 2.838 | | | 1236.277 | | boulder | glide |
| | 250 | 2.906 | | | 1236.209 | | cobble | riffle |
| | 260 | 2.746 | | | 1236.369 | | cobble | riffle |
| | 270 | 2.792 | | | 1236.323 | | cobble | riffle |

Reach 7, Site 3 Long Survey

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | | Corrected Data | | Dominant Substrate | Habitat Type | Comments |
|-----------------------|----------------------------|--------------------------|--------------------|--------------------------------|--------------------------|--------------------------------|-----------------------|-----------------|----------|
| | | Thalweg Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Thalweg Elevation (m) | Water Surface Elevation (m) | | | |
| TP3 | 280 | 2.841 | | | 1236.274 | | boulder | riffle | |
| | 290 | 2.889 | | | 1236.226 | | boulder | riffle | |
| | 300 | 2.977 | | | 1236.138 | | boulder | riffle | |
| | 300 | 2.980 | | | 1236.135 | | boulder | riffle | |
| | 310 | 3.031 | | | 1236.084 | | cobble | riffle | |
| | 320 | 3.339 | | | 1235.776 | | cobble | glide | |
| | 330 | 3.139 | | | 1235.976 | | cobble | glide | |
| | 340 | 1.632 | | | 1235.658 | | cobble | glide | |
| | 350 | 1.748 | | | 1235.542 | | cobble | glide | |
| | 360 | 1.703 | | | 1235.587 | | cobble | riffle | |
| | 370 | 1.691 | | | 1235.599 | | cobble | riffle | |
| | 380 | 1.732 | | | 1235.558 | | boulder | riffle | |
| | 390 | 1.901 | | | 1235.389 | | boulder | glide | |
| | 400 | 2.089 | | | 1235.201 | | boulder | glide | |
| | 410 | 2.076 | | | 1235.214 | | cobble | riffle | |
| | 420 | 2.122 | | | 1235.168 | | boulder | riffle | |
| | 430 | 2.111 | | | 1235.179 | | boulder | riffle | |
| TP4 | 440 | 2.287 | | | 1235.003 | | boulder | riffle | |
| | 450 | 2.327 | | | 1234.963 | | boulder | riffle | |
| | 460 | 2.518 | | | 1234.772 | | boulder | riffle | |
| | 470 | 2.872 | | | 1234.418 | | boulder | riffle | |
| | 480 | 3.064 | | | 1234.408 | | boulder | glide | |
| | 490 | 3.229 | | | 1234.243 | | boulder | glide | |
| | 500 | 3.380 | | | 1234.092 | | boulder | glide | |
| | 500 | 3.358 | | | 1234.114 | | cobble | glide | |
| | 510 | 3.539 | | | 1233.933 | | cobble | glide | |
| | 520 | 3.513 | | | 1233.959 | | cobble | glide | |
| | 530 | 3.533 | | | 1233.939 | | cobble | glide | |
| | 540 | 3.552 | | | 1233.920 | | cobble | glide | |
| | 550 | 3.452 | | | 1234.020 | | cobble | riffle | |
| | 560 | 3.339 | | | 1234.133 | | cobble | riffle | |
| | 570 | 3.289 | | | 1234.183 | | cobble | riffle | |
| | 580 | 3.401 | | | 1234.071 | | cobble | riffle | |
| | 590 | 3.823 | | | 1233.649 | | cobble | riffle | |



Cross sectional profile of a representative pool habitat unit of the Wigwam River in reach 7, study site 3.
Channel was dry at time of survey.

Reach 7, Site 3 Pool X-Sxn

Pool Cross Sectional Survey

Location: Wigwam River

Reach: 7

Site: 3

UTM: 655250E, 5438840N

Crew: KM/LC

Date: 25/09/2001

Benchmark Elevation:

TP1: 1237.545 m

pool cross section located at 0+170 m of longitudinal profile

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | Dominant Substrate | Comments | |
|-----------------------|----------------------------|-------------------------|--------------------|--------------------------------|-------------------------|--------------------------------|------------|-----------------------|
| | | Ground Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | Water Surface Elevation (m) | | |
| TP1* | 5.0 | 1.192 | | | 1237.499 | | vegetation | RUB start |
| | 6.0 | 2.406 | channel | | 1236.285 | channel | finer | |
| | 7.0 | 2.323 | is | | 1236.368 | is | finer | side channel |
| | 8.0 | 2.034 | dry | | 1236.657 | dry | finer | |
| | 9.0 | 1.876 | | | 1236.815 | | vegetation | |
| | 10.0 | 1.741 | | | 1236.950 | | vegetation | |
| | 11.0 | 1.671 | | | 1237.020 | | vegetation | |
| | 12.0 | 1.837 | | | 1236.854 | | vegetation | |
| | 13.0 | 1.662 | | | 1237.029 | | vegetation | |
| | 14.0 | 1.577 | | | 1237.114 | | vegetation | |
| | 15.0 | 1.512 | | | 1237.179 | | vegetation | |
| | 16.0 | 1.573 | | | 1237.118 | | vegetation | |
| | 17.0 | 1.549 | | | 1237.142 | | vegetation | |
| | 18.0 | 1.579 | | | 1237.112 | | vegetation | |
| | 19.0 | 1.502 | | | 1237.189 | | vegetation | |
| | 20.0 | 1.499 | | | 1237.192 | | vegetation | |
| | 21.0 | 1.484 | | | 1237.207 | | vegetation | |
| | 22.0 | 1.512 | | | 1237.179 | | vegetation | |
| | 23.0 | 1.536 | | | 1237.155 | | vegetation | |
| | 24.0 | 1.592 | | | 1237.099 | | vegetation | |
| | 25.0 | 1.589 | | | 1237.102 | | vegetation | |
| | 26.0 | 1.563 | | | 1237.128 | | vegetation | |
| | 27.0 | 1.673 | | | 1237.018 | | gravel | RUB bankfull 1237.018 |
| | 28.0 | 1.792 | | | 1236.899 | | gravel | 1237.018 |
| | 29.0 | 1.991 | | | 1236.700 | | gravel | 1237.018 |
| | 30.0 | 2.241 | | | 1236.450 | | gravel | 1237.018 |
| | 31.0 | 2.283 | | | 1236.408 | | gravel | 1237.018 |
| | 32.0 | 2.274 | | | 1236.417 | | finer | 1237.018 |
| | 33.0 | 1.969 | | | 1236.722 | | finer | 1237.018 |
| | 34.0 | 2.673 | | | 1236.018 | | finer | 1237.018 |
| | 35.0 | 2.866 | | | 1235.825 | | finer | 1237.018 |
| | 36.0 | 2.948 | | | 1235.743 | | cobble | 1237.018 |

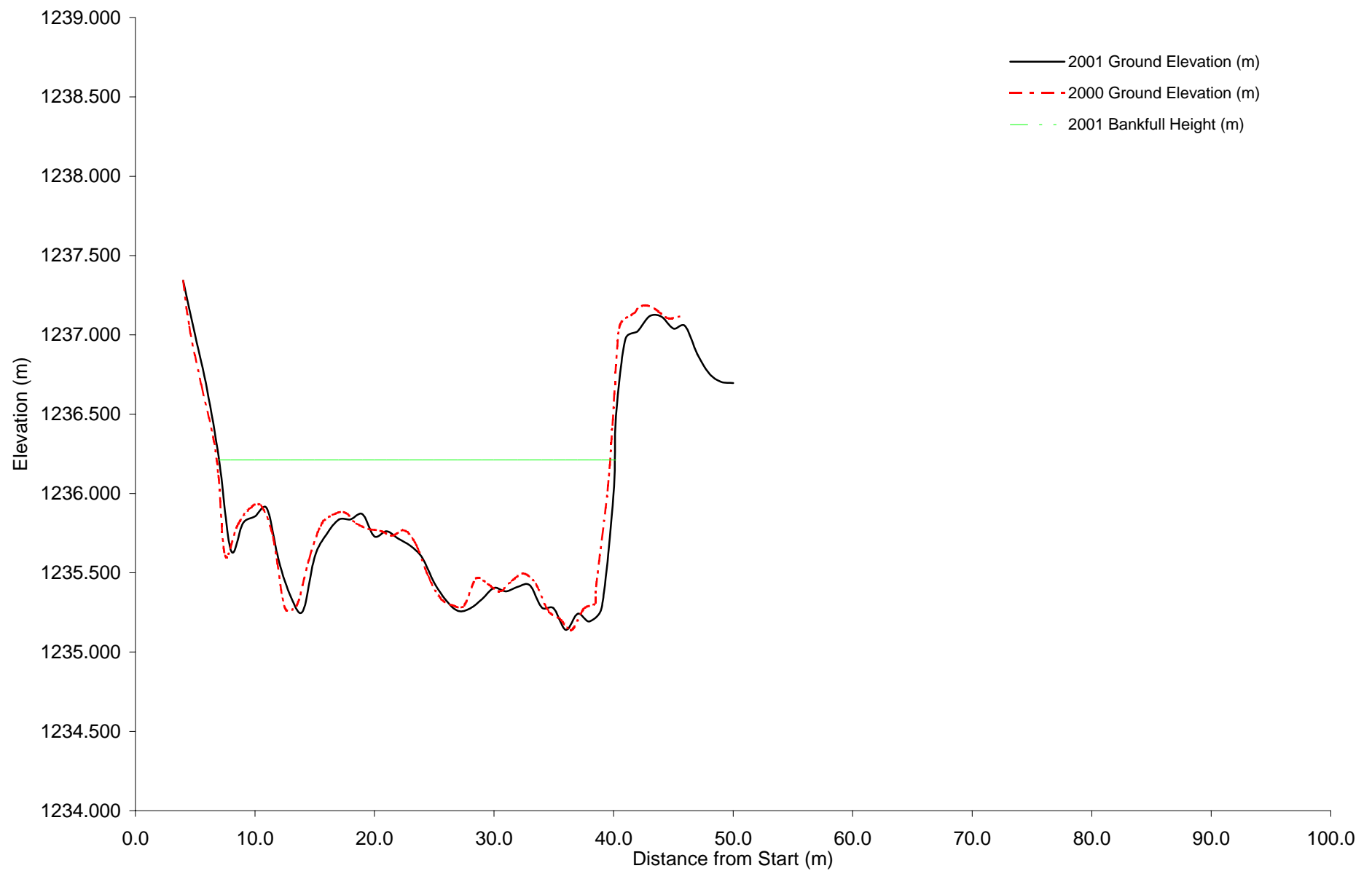
Reach 7, Site 3 Pool X-Sxn

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | Dominant Substrate | Comments |
|-----------------------|----------------------------|-------------------------|--------------------|--------------------------------|-------------------------|--------------------------------|------------------------------------|
| | | Ground Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | Water Surface Elevation (m) | |
| | 37.0 | 3.186 | | | 1235.505 | | gravel 1237.018 |
| | 38.0 | 3.277 | | | 1235.414 | | gravel 1237.018 |
| | 39.0 | 3.092 | | | 1235.599 | | gravel 1237.018 |
| | 40.0 | 2.079 | | | 1236.612 | | cobble 1237.018 |
| | 41.0 | 2.424 | | | 1236.267 | | cobble 1237.018 |
| | 42.0 | 2.286 | | | 1236.405 | | cobble 1237.018 |
| | 43.0 | 2.264 | | | 1236.427 | | cobble 1237.018 |
| | 44.0 | 2.213 | | | 1236.478 | | cobble 1237.018 |
| | 45.0 | 2.181 | | | 1236.510 | | cobble 1237.018 |
| | 46.0 | 2.144 | | | 1236.547 | | cobble 1237.018 |
| | 47.0 | 2.084 | | | 1236.607 | | cobble 1237.018 |
| | 48.0 | 1.987 | | | 1236.704 | | cobble 1237.018 |
| | 49.0 | 1.972 | | | 1236.719 | | gravel 1237.018 |
| | 50.0 | 1.916 | | | 1236.775 | | gravel 1237.018 |
| | 51.0 | 1.797 | | | 1236.894 | | gravel 1237.018 |
| | 52.0 | 1.742 | | | 1236.949 | | gravel 1237.018 |
| | 53.0 | 1.687 | | | 1237.004 | | gravel 1237.018 |
| | 54.0 | 1.648 | | | 1237.043 | | gravel 1237.018 |
| | 55.0 | 1.597 | | | 1237.094 | | gravel 1237.018 |
| | 56.0 | 1.609 | | | 1237.082 | | gravel 1237.018 |
| | 57.0 | 1.618 | | | 1237.073 | | gravel 1237.018 |
| | 58.0 | 1.642 | | | 1237.049 | | gravel 1237.018 |
| | 59.0 | 1.667 | | | 1237.024 | | gravel 1237.018 |
| | 60.0 | 1.742 | | | 1236.949 | | gravel 1237.018 |
| | 61.0 | 1.797 | | | 1236.894 | | gravel bankfull heigh 1237.018 |
| | 62.0 | 1.822 | | | 1236.869 | | gravel vegetated bar 1237.018 |
| | 63.0 | 1.832 | | | 1236.859 | | gravel 1237.018 |
| | 64.0 | 1.889 | | | 1236.802 | | gravel 1237.018 |
| | 65.0 | 1.968 | | | 1236.723 | | gravel small cottonwc 1237.018 |
| | 66.0 | 2.058 | | | 1236.633 | | gravel 1237.018 |
| | 67.0 | 2.097 | | | 1236.594 | | cobble 1237.018 |
| | 68.0 | 2.029 | | | 1236.662 | | cobble 1237.018 |
| | 69.0 | 1.812 | | | 1236.879 | | vegetation 1237.018 |
| | 70.0 | 1.719 | | | 1236.972 | | vegetation grass 1237.018 |
| | 71.0 | 1.709 | | | 1236.982 | | vegetation 1237.018 |
| | 72.0 | 1.661 | | | 1237.030 | | vegetation 1237.018 |
| | 73.0 | 1.607 | | | 1237.084 | | vegetation sparse cottonw 1237.018 |
| | 74.0 | 1.462 | | | 1237.229 | | vegetation 1237.018 |
| | 75.0 | 1.38 | | | 1237.311 | | vegetation 1237.018 |
| | 76.0 | 1.373 | | | 1237.318 | | vegetation 1237.018 |

Reach 7, Site 3 Pool X-Sxn

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | Dominant Substrate | Comments | |
|-----------------------|----------------------------|-------------------------|--------------------|--------------------------------|-------------------------|--------------------------------|------------|-------------------------|
| | | Ground Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | Water Surface Elevation (m) | | |
| | 77.0 | 1.561 | | | 1237.130 | | vegetation | 1237.018 |
| | 78.0 | 1.388 | | | 1237.303 | | vegetation | 1237.018 |
| | 79.0 | 1.334 | | | 1237.357 | | vegetation | 1237.018 |
| | 80.0 | 1.319 | | | 1237.372 | | vegetation | 1237.018 |
| | 81.0 | 1.463 | | | 1237.228 | | vegetation | 1237.018 |
| | 85.0 | 1.776 | | | 1236.915 | | vegetation | side channel 1237.018 |
| | 90.0 | 1.389 | | | 1237.302 | | gravel | 1237.018 |
| | 95.0 | 1.181 | | | 1237.510 | | gravel | 1237.018 |
| | 100.0 | 1.291 | | | 1237.400 | | gravel | 1237.018 |
| | 105.0 | 1.421 | | | 1237.270 | | gravel | 1237.018 |
| | 108.0 | 1.62 | | | 1237.071 | | gravel | bankfull 1237.018 |
| | 109.0 | 1.825 | | | 1236.866 | | finer | 1237.018 |
| | 110.0 | 2.136 | | | 1236.555 | | finer | 1237.018 |
| | 111.0 | 2.281 | | | 1236.410 | | gravel | 1237.018 |
| | 112.0 | 2.409 | | | 1236.282 | | gravel | 1237.018 |
| | 113.0 | 2.48 | | | 1236.211 | | gravel | LUB bankfull h 1237.018 |
| | 114.0 | 2.576 | | | 1236.115 | | gravel | 1237.018 |
| | 115.0 | 1.986 | | | 1236.705 | | boulder | 1237.018 |
| | 116.0 | 2.453 | | | 1236.238 | | gravel | 1237.018 |
| | 117.0 | 2.175 | | | 1236.516 | | gravel | bankfull 1237.018 |
| | 118.0 | 1.848 | | | 1236.843 | | gravel | |
| | 119.0 | 1.369 | | | 1237.322 | | finer | |
| | 120.0 | 0.974 | | | 1237.717 | | finer | |

* TP1 backsight=2.189 m, height of instrument = 1239.691 m



Cross sectional profile of a representative riffle habitat unit of the Wigwam River in reach 7, study site 3.
Channel was dry at time of survey.

Reach 7, Site 3 Riffle X-Sxn

Riffle Cross Sectional Survey

Location: Wigwam River

Reach: 7

Site: 3

UTM: 655186E, 5438950N

Crew: KM/LC

Date: 25/09/2001

Benchmark Elevation:

TP2: 1236.601 m

riffle cross section located at 0+285m of longitudinal profile

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | Dominant Substrate | Comments |
|--------------------|-------------------------|----------------------|-----------------|-----------------------------|----------------------|--------------------|---------------------|
| | | Ground Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | | |
| TP2* | 4.0 | 0.112 | | | 1237.341 | vegetation | RUB start |
| | 5.0 | 0.452 | channel | | 1237.001 | | |
| | 6.0 | 0.802 | is | | 1236.651 | | |
| | 7.0 | 1.242 | dry | | 1236.211 | | RUB bankfull height |
| | 8.0 | 1.813 | | | 1235.640 | boulder | side channel outlet |
| | 9.0 | 1.642 | | | 1235.811 | gravel | |
| | 10.0 | 1.598 | | | 1235.855 | gravel | |
| | 11.0 | 1.547 | | | 1235.906 | sand | |
| | 12.0 | 1.877 | | | 1235.576 | sand | |
| | 13.0 | 2.105 | | | 1235.348 | sand | |
| | 14.0 | 2.196 | | | 1235.257 | gravel | |
| | 15.0 | 1.853 | | | 1235.600 | gravel | |
| | 16.0 | 1.711 | | | 1235.742 | cobble | |
| | 17.0 | 1.618 | | | 1235.835 | gravel | |
| | 18.0 | 1.617 | | | 1235.836 | gravel | |
| | 19.0 | 1.584 | | | 1235.869 | gravel | |
| | 20.0 | 1.723 | | | 1235.730 | gravel | |
| | 21.0 | 1.692 | | | 1235.761 | gravel | |
| | 22.0 | 1.738 | | | 1235.715 | gravel | |
| | 23.0 | 1.782 | | | 1235.671 | gravel | |
| | 24.0 | 1.857 | | | 1235.596 | cobble | |
| | 25.0 | 2.018 | | | 1235.435 | cobble | |
| | 26.0 | 2.128 | | | 1235.325 | cobble | |
| | 27.0 | 2.194 | | | 1235.259 | cobble | |
| | 28.0 | 2.178 | | | 1235.275 | cobble | |
| | 29.0 | 2.119 | | | 1235.334 | cobble | |
| | 30.0 | 2.049 | | | 1235.404 | cobble | |
| | 31.0 | 2.071 | | | 1235.382 | cobble | |
| | 32.0 | 2.041 | | | 1235.412 | cobble | |
| | 33.0 | 2.032 | | | 1235.421 | cobble | |
| | 34.0 | 2.172 | | | 1235.281 | boulder | main channel |
| | 35.0 | 2.178 | | | 1235.275 | boulder | |
| | 36.0 | 2.313 | | | 1235.140 | boulder | |

Reach 7, Site 3 Riffle X-Sxn

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | Dominant Substrate | Comments |
|-----------------------|----------------------------|-------------------------|--------------------|--------------------------------|-------------------------|--------------------------------|----------|
| | | Ground Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | Water Surface Elevation (m) | |
| | 37.0 | 2.211 | | | 1235.242 | | boulder |
| | 38.0 | 2.260 | | | 1235.193 | | boulder |
| | 39.0 | 2.172 | | | 1235.281 | | gravel |
| | 40.0 | 1.446 | | | 1236.007 | | gravel |
| | 40.2 | 0.964 | | | 1236.489 | | gravel |
| | 41.0 | 0.478 | | | 1236.975 | | gravel |
| | 42.0 | 0.432 | | | 1237.021 | | gravel |
| | 43.0 | 0.335 | | | 1237.118 | | gravel |
| | 44.0 | 0.338 | | | 1237.115 | | gravel |
| | 45.0 | 0.413 | | | 1237.040 | | gravel |
| | 46.0 | 0.398 | | | 1237.055 | | gravel |
| | 47.0 | 0.574 | | | 1236.879 | | gravel |
| | 48.0 | 0.697 | | | 1236.756 | | gravel |
| | 49.0 | 0.75 | | | 1236.703 | | gravel |
| | 50.0 | 0.757 | | | 1236.696 | | gravel |

TP2* backsight = 1.852 m, height of instrument = 1237.453 m

R7,S3 Differential Level Loop

Differential Levelling Loop - Reach 7, Site 3

Date: 27/09/2001

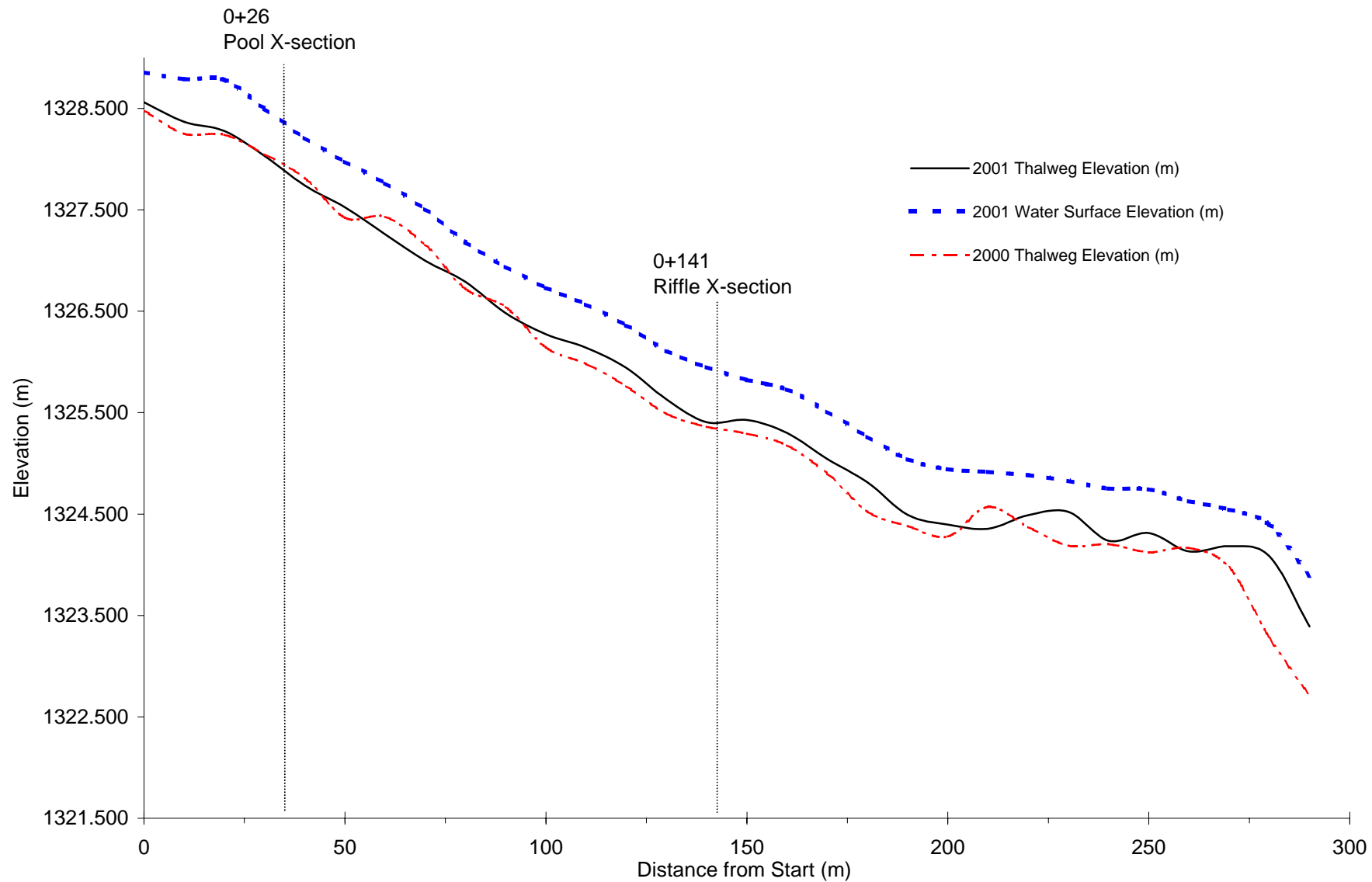
Field (Arbitrary) Elevations (m)

| Station | Backsight | Height of Instrument | Foresight | Elevation |
|---------|-----------|-------------------------|-----------|--------------|
| BM1 | 0.509 | 5.509 | | 5.000 |
| TP1 | 2.212 | 4.800 | 2.921 | 2.588 |
| TP2 | 2.519 | 4.115 | 3.204 | 1.596 |
| TP3 | 2.178 | 3.290 | 3.003 | 1.112 |
| TP4 | 2.741 | 3.472 | 2.559 | 0.731 |
| BM2 | | 2.721 | 0.751 | 2.721 |
| BM2 | 0.751 | 3.472 | | 2.721 |
| TP4 | 2.571 | 3.304 | 2.739 | 0.733 |
| TP3 | 3.051 | 4.165 | 2.190 | 1.114 |
| TP2 | 3.213 | 4.819 | 2.559 | 1.606 |
| TP1 | 3.010 | 5.512 | 2.317 | 2.502 |
| BM1 | | | 0.516 | 4.996 |
| | | | | error=-0.004 |

True Elevations (m)

| Station | Backsight | Height of Instrument | Foresight | Elevation |
|---------|-----------|-------------------------|-----------|--------------|
| BM1 | 0.509 | 1240.509 | | 1240.000 |
| TP1 | 2.212 | 1239.800 | 2.921 | 1237.588 |
| TP2 | 2.519 | 1239.115 | 3.204 | 1236.596 |
| TP3 | 2.178 | 1238.290 | 3.003 | 1236.112 |
| TP4 | 2.741 | 1238.472 | 2.559 | 1235.731 |
| BM2 | | 1237.721 | 0.751 | 1237.721 |
| BM2 | 0.751 | 1238.472 | | 1237.721 |
| TP4 | 2.571 | 1238.304 | 2.739 | 1235.733 |
| TP3 | 3.051 | 1239.165 | 2.190 | 1236.114 |
| TP2 | 3.213 | 1239.819 | 2.559 | 1236.606 |
| TP1 | 3.010 | 1240.512 | 2.317 | 1237.502 |
| BM1 | | | 0.516 | 1239.996 |
| | | | | error=-0.004 |

| Benchmark Elevations (m) | | |
|--------------------------|----------|----------|
| | 2000 | 2001 |
| BM1 | 1240.000 | 1240.000 |
| BM2 | 1237.712 | 1237.721 |



Longitudinal profile of a representative two meander lengths of the Wigwam River in reach 9, study site 4.

Reach 9, Site 4 Long Survey

Longitudinal Survey

Location: Wigwam River

Reach: 9

Site: 4

UTM: start 661031E, 5432738N

end 654977E, 5439074N

Crew: KM/LC

Date: 26/09/2001

Benchmark UTM:

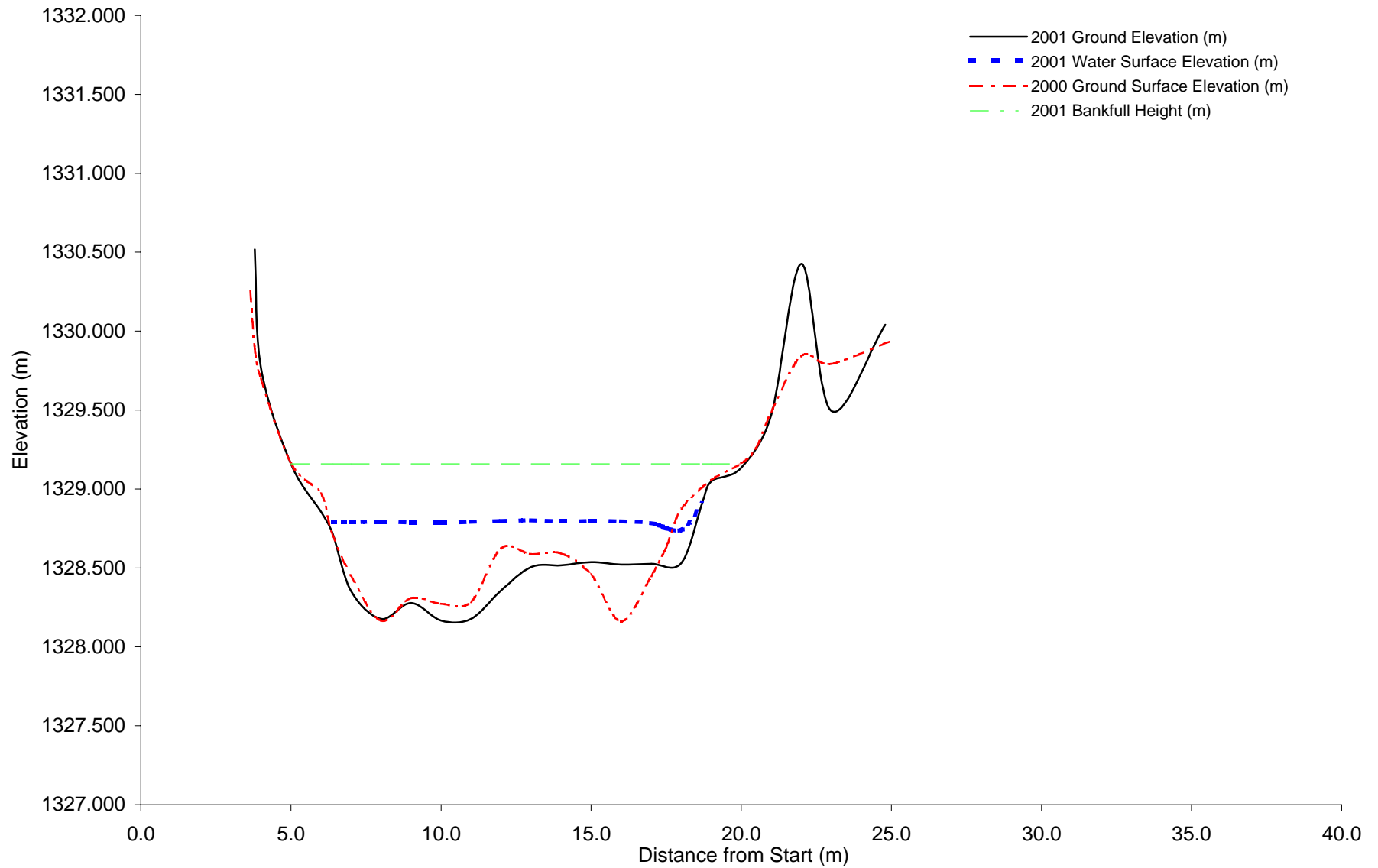
BM1: 661028E, 5432729N

Benchmark Elevations:

BM1: 1330.000

BM2: 1327.388

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | | Corrected Data | | Dominant Substrate | Habitat Type | Comments |
|--------------------|-------------------------|-----------------------|-----------------|-----------------------------|-----------------------|-----------------------------|--------------------|--------------|--------------|
| | | Thalweg Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Thalweg Elevation (m) | Water Surface Elevation (m) | | | |
| BM1 | 0 | 1.476 | 0.295 | 1.181 | 1328.561 | 1328.856 | boulder | glide | |
| | 10 | 1.668 | 0.420 | 1.248 | 1328.369 | 1328.789 | boulder | glide | |
| | 20 | 1.759 | 0.505 | 1.254 | 1328.278 | 1328.783 | boulder | glide | |
| | 30 | 2.006 | 0.470 | 1.536 | 1328.031 | 1328.501 | boulder | riffle | |
| | 40 | 2.296 | 0.470 | 1.826 | 1327.741 | 1328.211 | boulder | riffle | |
| | 50 | 2.511 | 0.450 | 2.061 | 1327.526 | 1327.976 | boulder | riffle | |
| | 60 | 2.779 | 0.505 | 2.274 | 1327.258 | 1327.763 | boulder | riffle | |
| | 70 | 3.038 | 0.510 | 2.528 | 1326.999 | 1327.509 | boulder | riffle | |
| | 80 | 3.248 | 0.390 | 2.858 | 1326.789 | 1327.179 | cobble | pool | |
| TP1 | 90 | 3.557 | 0.460 | 3.097 | 1326.480 | 1326.940 | boulder | riffle | |
| | 100 | 1.517 | 0.460 | 1.057 | 1326.272 | 1326.732 | boulder | riffle | |
| | 110 | 1.648 | 0.425 | 1.223 | 1326.141 | 1326.566 | boulder | riffle | |
| | 120 | 1.847 | 0.420 | 1.427 | 1325.942 | 1326.362 | boulder | riffle | |
| | 130 | 2.159 | 0.480 | 1.679 | 1325.630 | 1326.110 | boulder | riffle | |
| | 140 | 2.384 | 0.545 | 1.839 | 1325.405 | 1325.950 | boulder | riffle | |
| | 150 | 2.361 | 0.395 | 1.966 | 1325.428 | 1325.823 | boulder | riffle | |
| | 160 | 2.489 | 0.430 | 2.059 | 1325.300 | 1325.730 | boulder | riffle | |
| | 170 | 2.747 | 0.470 | 2.277 | 1325.042 | 1325.512 | boulder | riffle | |
| TP2 | 180 | 2.976 | 0.450 | 2.526 | 1324.813 | 1325.263 | boulder | riffle | |
| | 190 | 3.298 | 0.550 | 2.748 | 1324.491 | 1325.041 | cobble | glide | Rabbit Creek |
| | 200 | 2.083 | 0.545 | 1.538 | 1324.397 | 1324.942 | cobble | glide | |
| | 210 | 2.125 | 0.560 | 1.565 | 1324.355 | 1324.915 | cobble | glide | |
| | 220 | 1.991 | 0.395 | 1.596 | 1324.489 | 1324.884 | cobble | glide | |
| | 230 | 1.958 | 0.305 | 1.653 | 1324.522 | 1324.827 | cobble | glide | |
| | 240 | 2.244 | 0.515 | 1.729 | 1324.236 | 1324.751 | boulder | riffle | |
| | 250 | 2.167 | 0.430 | 1.737 | 1324.313 | 1324.743 | boulder | riffle | |
| | 260 | 2.348 | 0.495 | 1.853 | 1324.132 | 1324.627 | cobble | riffle | |
| | 270 | 2.296 | 0.360 | 1.936 | 1324.184 | 1324.544 | cobble | riffle | |
| | 280 | 2.395 | 0.310 | 2.085 | 1324.085 | 1324.395 | boulder | cascade | |
| | 290 | 3.089 | 0.500 | 2.589 | 1323.391 | 1323.891 | boulder | cascade | end of reach |



Cross sectional profile of a representative pool habitat unit of the Wigwam River in reach 9, study site 4.

Reach 9, Site 4 Pool X-Sxn

Pool Cross Sectional Survey

Location: Wigwam River

Reach: 9

Site: 4

pool cross section at 0+26m of longitudinal survey

UTM: 661005E, 5432852N

Crew: KM/LC

Date: 26/09/2001

Benchmark UTM:

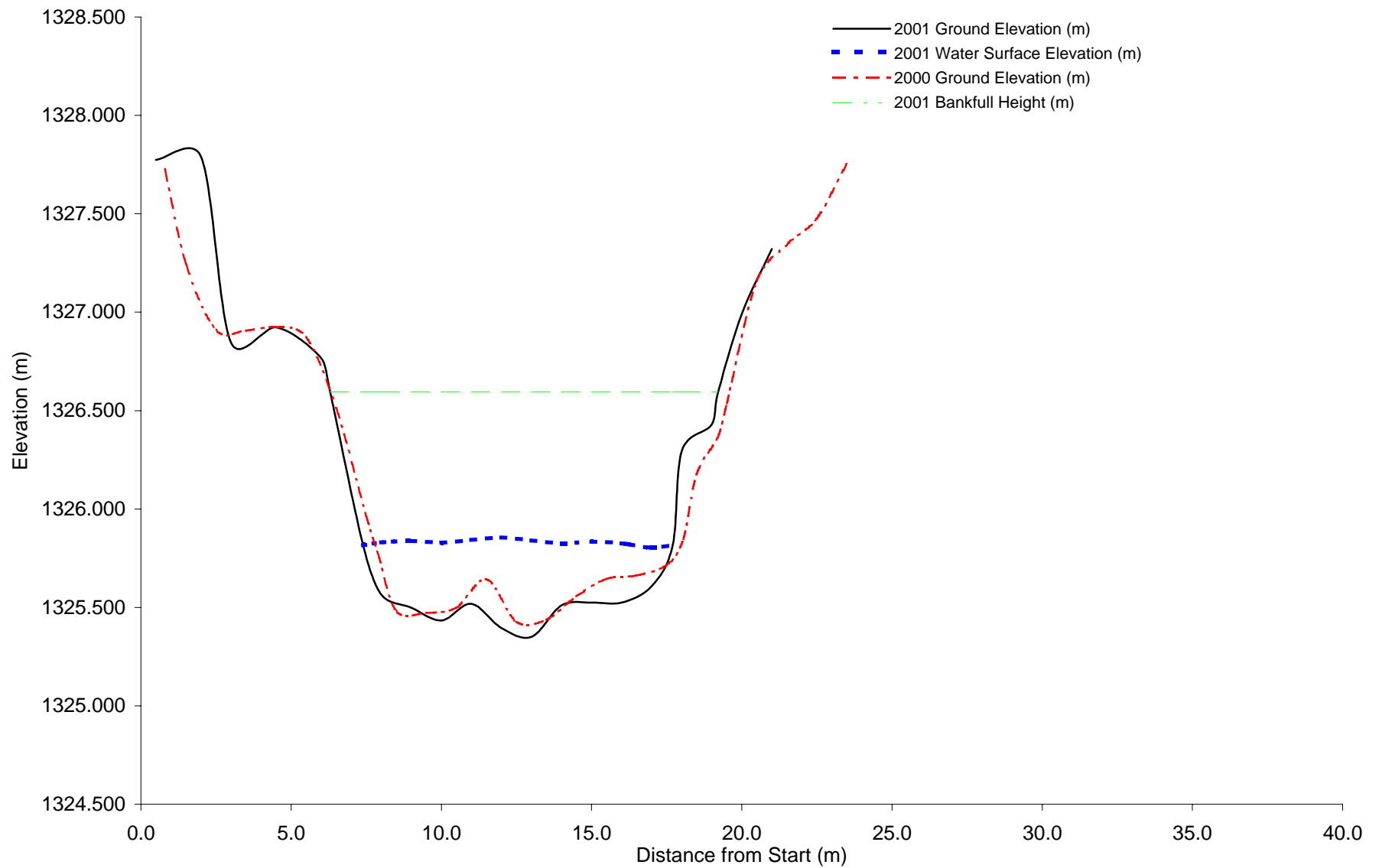
BM1: 661028E, 5432729N

Benchmark Elevation:

BM1: 1330.000 m

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | | Corrected Data | | Dominant Substrate | Comments |
|-----------------------|----------------------------|-------------------------|--------------------|--------------------------------|-------------------------|--------------------------------|-----------------------|-----------------|
| | | Ground Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | Water Surface Elevation (m) | | |
| BM1* | 3.8 | 0.151 | | | 1330.518 | | vegetation | RUB start |
| | 4.0 | 0.899 | | | 1329.770 | | finer | |
| | 5.0 | 1.509 | | | 1329.160 | | finer | RUB bankfull |
| | 6.0 | 1.813 | | | 1328.856 | | vegetation | |
| | 6.4 | 1.989 | 0.08 | 1.909 | 1328.710 | 1328.790 | boulder | RUB wetted edge |
| | 7.0 | 2.343 | 0.435 | 1.908 | 1328.356 | 1328.791 | boulder | |
| | 8.0 | 2.522 | 0.615 | 1.907 | 1328.177 | 1328.792 | boulder | |
| | 9.0 | 2.421 | 0.51 | 1.911 | 1328.278 | 1328.788 | cobble | |
| | 10.0 | 2.532 | 0.62 | 1.912 | 1328.167 | 1328.787 | cobble | |
| | 11.0 | 2.522 | 0.615 | 1.907 | 1328.177 | 1328.792 | cobble | |
| | 12.0 | 2.342 | 0.44 | 1.902 | 1328.357 | 1328.797 | gravel | |
| | 13.0 | 2.193 | 0.295 | 1.898 | 1328.506 | 1328.801 | gravel | |
| | 14.0 | 2.183 | 0.28 | 1.903 | 1328.516 | 1328.796 | gravel | |
| | 15.0 | 2.162 | 0.26 | 1.902 | 1328.537 | 1328.797 | gravel | |
| | 16.0 | 2.178 | 0.275 | 1.903 | 1328.521 | 1328.796 | gravel | |
| | 17.0 | 2.174 | 0.26 | 1.914 | 1328.525 | 1328.785 | gravel | |
| | 18.0 | 2.169 | 0.21 | 1.959 | 1328.530 | 1328.740 | gravel | |
| | 18.7 | 1.79 | 0 | 1.79 | 1328.909 | 1328.909 | gravel | LUB wetted edge |
| | 19.0 | 1.652 | | | 1329.047 | | boulder | |
| | 20.0 | 1.564 | | | 1329.135 | | vegetation | LUB bankfull |
| | 21.0 | 1.229 | | | 1329.470 | | vegetation | |
| | 22.0 | 0.272 | | | 1330.427 | | vegetation | |
| | 23.0 | 1.203 | | | 1329.496 | | vegetation | |
| | 24.8 | 0.659 | | | 1330.040 | | vegetation | |

* BM1 backsight = 0.699 m, height of instrument = 1330.699 m



Cross sectional profile of a representative riffle habitat unit of the Wigwam River in reach 9, study site 4.

Reach 9, Site 4 Riffle X-Sxn

Riffle Cross Sectional Survey

Location: Wigwam River

Reach: 9

Site: 4

cross section located at 0+141m of longitudinal survey

UTM: 660942E, 5432911N

Crew: KM/LC

Date: 26/09/2001

Benchmark UTM

BM1: 661028E, 5432729N

Benchmark Elevation

BM1: 1330.000 m

TP1: 1327.436 m

| Ground Station No. | Distance from Start (m) | Uncorrected Data | | Corrected Data | | Dominant Substrate | Comments |
|-----------------------|----------------------------|------------------|--------------------|--------------------------------|-------------------------|--------------------------------|--------------------------------|
| | | Elevation (m) | Water Level (m) | Water Surface Elevation (m) | Ground Elevation (m) | Water Surface Elevation (m) | |
| TP1 | 0.5 | 0.015 | | | 1327.774 | | vegetation RUB start |
| | 2.0 | | | | 1327.789 | | vegetation |
| | 3.0 | 0.943 | | | 1326.846 | | vegetation |
| | 4.5 | 0.866 | | | 1326.923 | | vegetation |
| | 6.0 | 1.023 | | | 1326.766 | | vegetation |
| | 6.3 | 1.194 | | | 1326.595 | | vegetation RUB bankfull height |
| | 7.4 | 1.973 | 0 | 1.973 | 1325.816 | 1325.816 | boulder RUB wetted edge |
| | 8.0 | 2.223 | 0.265 | 1.958 | 1325.566 | 1325.831 | gravel |
| | 9.0 | 2.291 | 0.34 | 1.951 | 1325.498 | 1325.838 | boulder |
| | 10.0 | 2.355 | 0.395 | 1.96 | 1325.434 | 1325.829 | cobble |
| | 11.0 | 2.271 | 0.325 | 1.946 | 1325.518 | 1325.843 | cobble |
| | 12.0 | 2.394 | 0.46 | 1.934 | 1325.395 | 1325.855 | boulder |
| | 13.0 | 2.439 | 0.49 | 1.949 | 1325.350 | 1325.840 | boulder |
| | 14.0 | 2.278 | 0.315 | 1.963 | 1325.511 | 1325.826 | boulder |
| | 15.0 | 2.265 | 0.31 | 1.955 | 1325.524 | 1325.834 | boulder |
| | 16.0 | 2.264 | 0.3 | 1.964 | 1325.525 | 1325.825 | boulder |
| | 17.0 | 2.181 | 0.195 | 1.986 | 1325.608 | 1325.803 | boulder |
| | 17.7 | 1.972 | 0 | 1.972 | 1325.817 | 1325.817 | boulder LUB wetted edge |
| | 18.0 | 1.493 | | | 1326.296 | | boulder |
| | 19.0 | 1.361 | | | 1326.428 | | boulder |
| | 19.2 | 1.201 | | | 1326.588 | | cobble LUB bankfull height |
| | 20.0 | 0.799 | | | 1326.990 | | cobble |
| | 21.0 | 0.468 | | | 1327.321 | | vegetation |

R9, S4 Differential Level Loop

Differential Levelling Loop - Reach 9, Site 4

Date: 26/09/2001

Field (Arbitrary) Elevations (m)

| Station | Backsight | Height of Instrument | Foresight | Elevation |
|---------|-----------|----------------------|-----------|----------------|
| BM1 | 0.037 | 10.037 | | 10.000 |
| TP1 | 0.353 | 7.789 | 2.601 | 7.436 |
| TP2 | 1.141 | 6.480 | 2.45 | 5.339 |
| BM3 | | 4.464 | 2.016 | 4.464 |
| BM3 | 2.016 | 6.480 | | 4.464 |
| TP2 | 2.457 | 7.796 | 1.141 | 5.339 |
| TP1 | 2.754 | 10.190 | 0.36 | 7.436 |
| BM1 | | 10.001 | 0.189 | 10.001 |
| | | | | error = +0.001 |

True Elevations (m)

| Station | Backsight | Height of Instrument | Foresight | Elevation |
|---------|-----------|----------------------|-----------|----------------|
| BM1 | 0.037 | 1330.037 | | 1330.000 |
| TP1 | 0.353 | 1327.789 | 2.601 | 1327.436 |
| TP2 | 1.141 | 1326.480 | 2.45 | 1325.339 |
| BM3 | | 1324.464 | 2.016 | 1324.464 |
| BM3 | 2.016 | 1326.480 | | 1324.464 |
| TP2 | 2.457 | 1327.796 | 1.141 | 1325.339 |
| TP1 | 2.754 | 1330.190 | 0.36 | 1327.436 |
| BM1 | | 1330.001 | 0.189 | 1330.001 |
| | | | | error = +0.001 |

| Benchmark Elevations (m) | | |
|--------------------------|----------|----------|
| | 2000 | 2001 |
| BM1 | 1330.000 | 1330.000 |
| BM2 | 1327.573 | 1327.388 |
| BM3 | 1324.374 | 1324.464 |

Appendix E

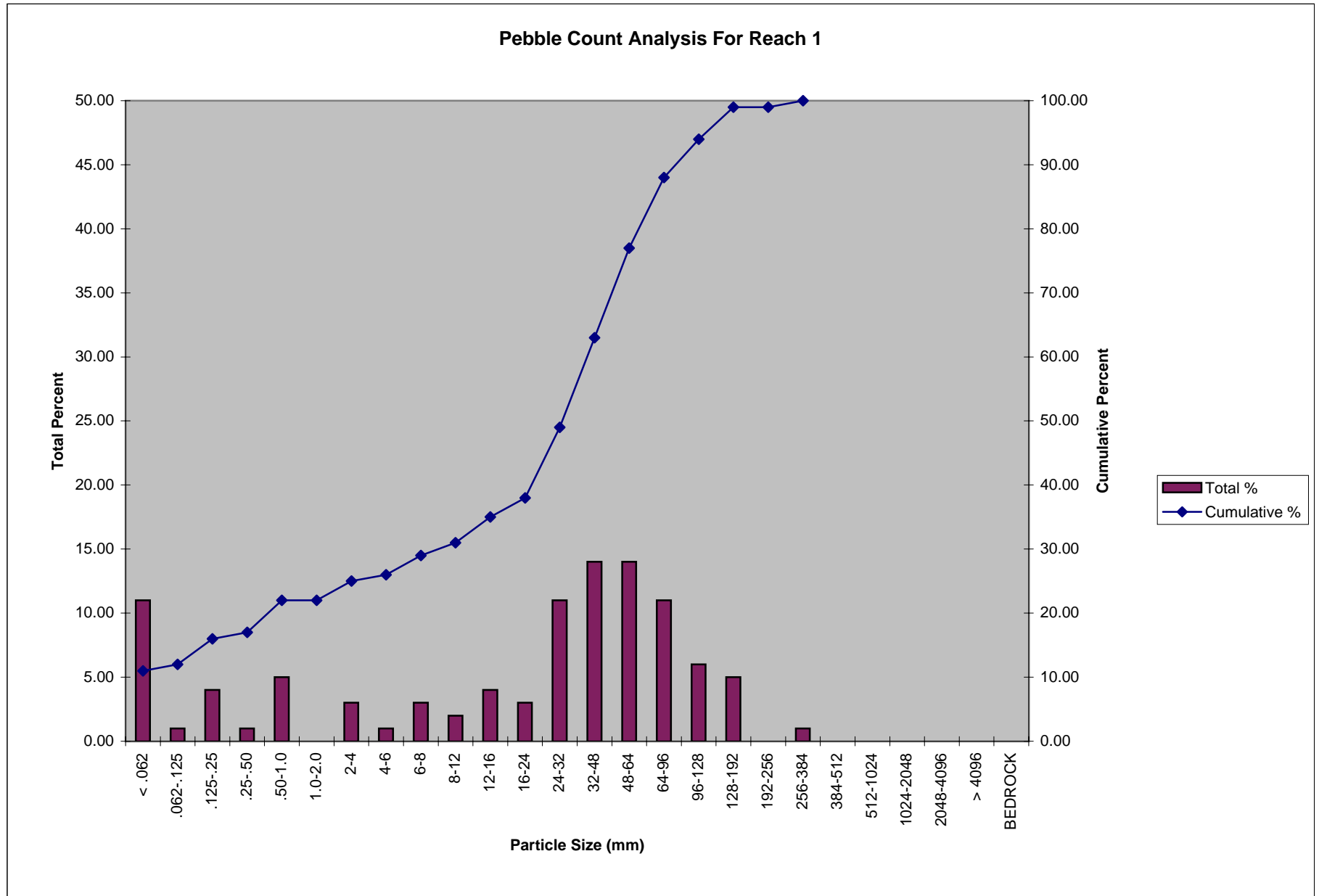
Pebble Count Data

Bighorn Creek, Reach 1 Pebble Count

| | |
|----------|---------|
| Station: | Reach 1 |
|----------|---------|

| Particle Class | Particle Size (mm) | Number | Total % | Cumulative % |
|----------------|--------------------|--------|---------|--------------|
| Silt/Clay | < .062 | 11 | 11.00 | 11.00 |
| VFS | .062-.125 | 1 | 1.00 | 12.00 |
| FS | .125-.25 | 4 | 4.00 | 16.00 |
| MS | .25-.50 | 1 | 1.00 | 17.00 |
| CS | .50-1.0 | 5 | 5.00 | 22.00 |
| VCS | 1.0-2.0 | | 0.00 | 22.00 |
| VFG | 2-4 | 3 | 3.00 | 25.00 |
| FG | 4-6 | 1 | 1.00 | 26.00 |
| FG | 6-8 | 3 | 3.00 | 29.00 |
| MG | 8-12 | 2 | 2.00 | 31.00 |
| MG | 12-16 | 4 | 4.00 | 35.00 |
| CG | 16-24 | 3 | 3.00 | 38.00 |
| CG | 24-32 | 11 | 11.00 | 49.00 |
| VCG | 32-48 | 14 | 14.00 | 63.00 |
| VCG | 48-64 | 14 | 14.00 | 77.00 |
| SC | 64-96 | 11 | 11.00 | 88.00 |
| SC | 96-128 | 6 | 6.00 | 94.00 |
| LC | 128-192 | 5 | 5.00 | 99.00 |
| LC | 192-256 | | 0.00 | 99.00 |
| SB | 256-384 | 1 | 1.00 | 100.00 |
| SB | 384-512 | | 0.00 | |
| MB | 512-1024 | | 0.00 | |
| LB | 1024-2048 | | 0.00 | |
| VLB | 2048-4096 | | 0.00 | |
| VLB | > 4096 | | 0.00 | |
| | BEDROCK | | 0.00 | |

Bighorn Creek Chart 1

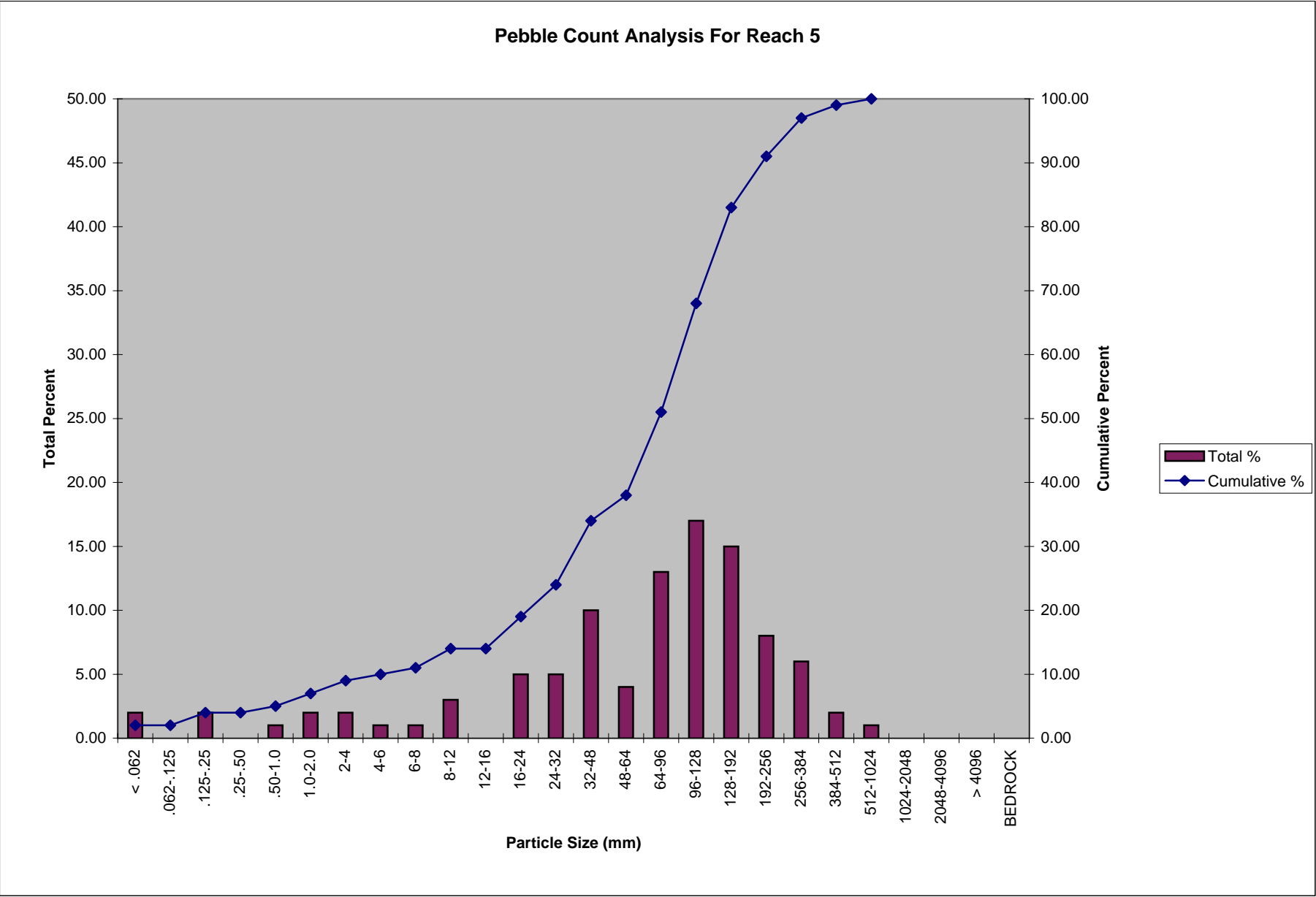


Wigwam River, Reach 5 Pebble Count

| | |
|----------|---------|
| Station: | Reach 5 |
|----------|---------|

| Particle Class | Particle Size (mm) | Number | Total % | Cumulative % |
|----------------|--------------------|--------|---------|--------------|
| Silt/Clay | < .062 | 2 | 2.00 | 2.00 |
| VFS | .062-.125 | | 0.00 | 2.00 |
| FS | .125-.25 | 2 | 2.00 | 4.00 |
| MS | .25-.50 | | 0.00 | 4.00 |
| CS | .50-1.0 | 1 | 1.00 | 5.00 |
| VCS | 1.0-2.0 | 2 | 2.00 | 7.00 |
| VFG | 2-4 | 2 | 2.00 | 9.00 |
| FG | 4-6 | 1 | 1.00 | 10.00 |
| FG | 6-8 | 1 | 1.00 | 11.00 |
| MG | 8-12 | 3 | 3.00 | 14.00 |
| MG | 12-16 | | 0.00 | 14.00 |
| CG | 16-24 | 5 | 5.00 | 19.00 |
| CG | 24-32 | 5 | 5.00 | 24.00 |
| VCG | 32-48 | 10 | 10.00 | 34.00 |
| VCG | 48-64 | 4 | 4.00 | 38.00 |
| SC | 64-96 | 13 | 13.00 | 51.00 |
| SC | 96-128 | 17 | 17.00 | 68.00 |
| LC | 128-192 | 15 | 15.00 | 83.00 |
| LC | 192-256 | 8 | 8.00 | 91.00 |
| SB | 256-384 | 6 | 6.00 | 97.00 |
| SB | 384-512 | 2 | 2.00 | 99.00 |
| MB | 512-1024 | 1 | 1.00 | 100.00 |
| LB | 1024-2048 | | 0.00 | |
| VLB | 2048-4096 | | 0.00 | |
| VLB | > 4096 | | 0.00 | |
| | BEDROCK | | 0.00 | |

Reach 5, Site 1 Chart 1

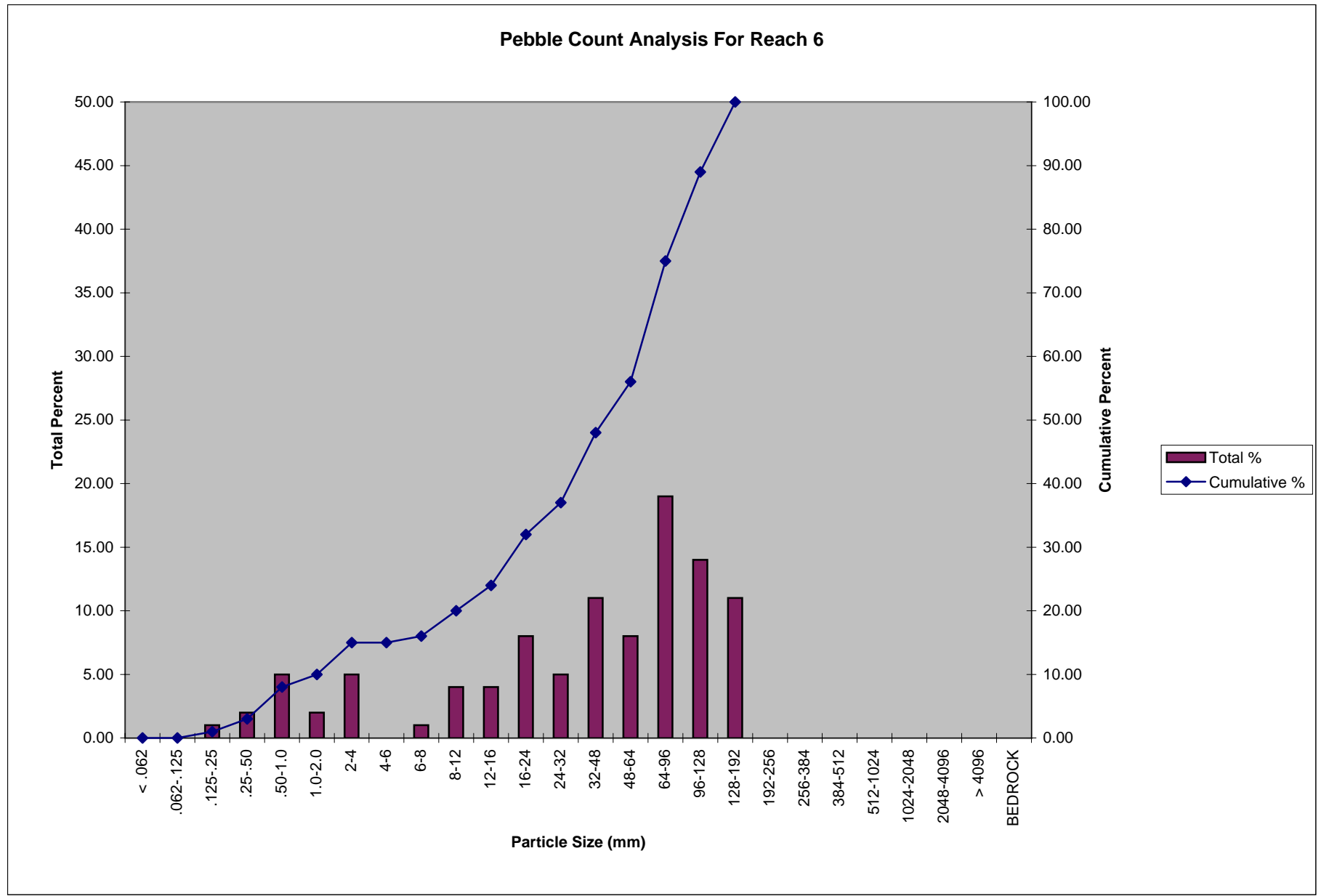


Wigwam River Reach 6, Site 2 Pebble Count

| | |
|----------|---------|
| Station: | Reach 6 |
|----------|---------|

| Particle Class | Particle Size (mm) | Number | Total % | Cumulative % |
|----------------|--------------------|--------|---------|--------------|
| Silt/Clay | < .062 | | 0.00 | 0.00 |
| VFS | .062-.125 | | 0.00 | 0.00 |
| FS | .125-.25 | 1 | 1.00 | 1.00 |
| MS | .25-.50 | 2 | 2.00 | 3.00 |
| CS | .50-1.0 | 5 | 5.00 | 8.00 |
| VCS | 1.0-2.0 | 2 | 2.00 | 10.00 |
| VFG | 2-4 | 5 | 5.00 | 15.00 |
| FG | 4-6 | | 0.00 | 15.00 |
| FG | 6-8 | 1 | 1.00 | 16.00 |
| MG | 8-12 | 4 | 4.00 | 20.00 |
| MG | 12-16 | 4 | 4.00 | 24.00 |
| CG | 16-24 | 8 | 8.00 | 32.00 |
| CG | 24-32 | 5 | 5.00 | 37.00 |
| VCG | 32-48 | 11 | 11.00 | 48.00 |
| VCG | 48-64 | 8 | 8.00 | 56.00 |
| SC | 64-96 | 19 | 19.00 | 75.00 |
| SC | 96-128 | 14 | 14.00 | 89.00 |
| LC | 128-192 | 11 | 11.00 | 100.00 |
| LC | 192-256 | | 0.00 | |
| SB | 256-384 | | 0.00 | |
| SB | 384-512 | | 0.00 | |
| MB | 512-1024 | | 0.00 | |
| LB | 1024-2048 | | 0.00 | |
| VLB | 2048-4096 | | 0.00 | |
| VLB | > 4096 | | 0.00 | |
| | BEDROCK | | 0.00 | |

Reach 6, Site 2 Chart 1

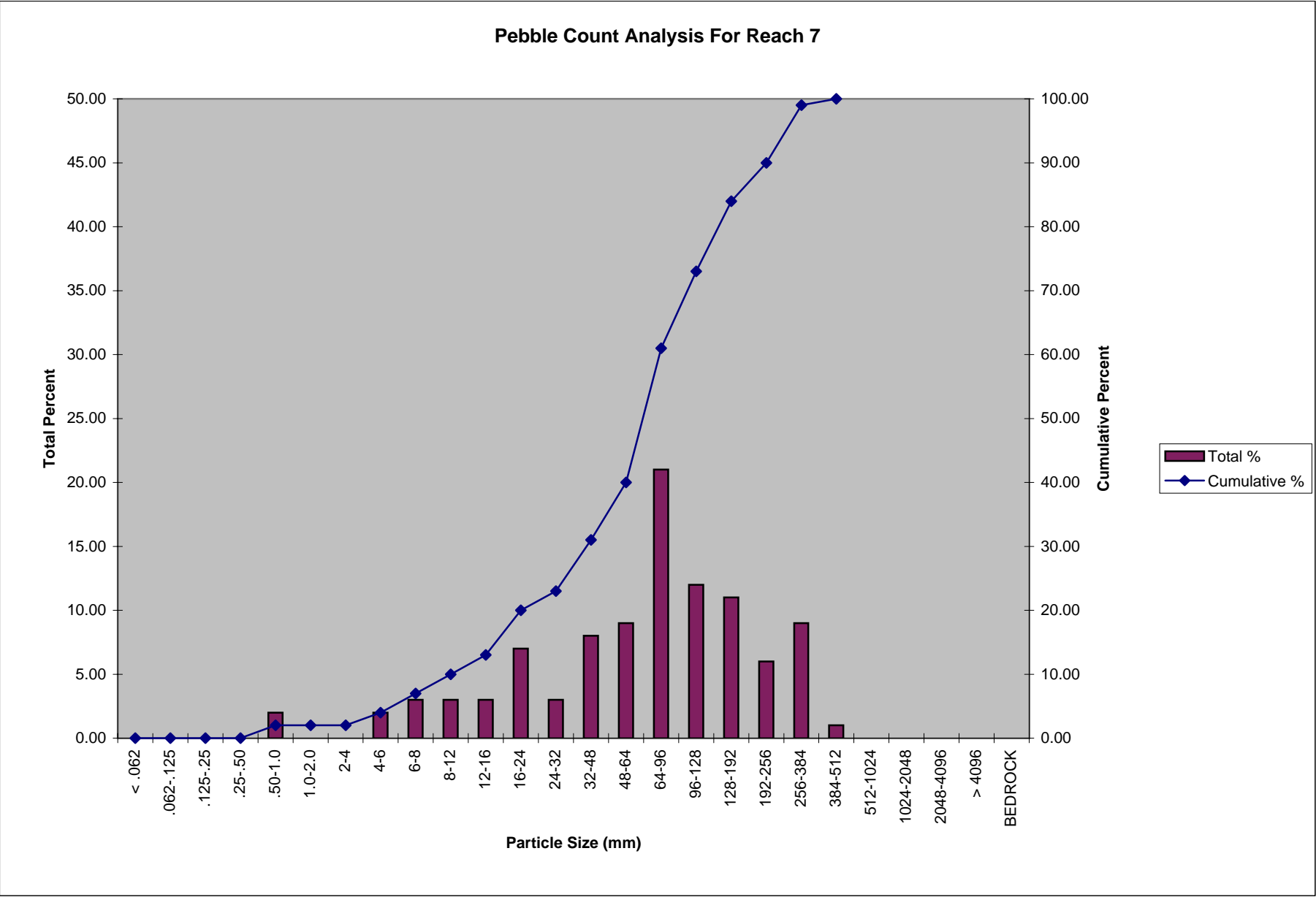


Wigwam River, Reach 7 Pebble Count

| | |
|----------|---------|
| Station: | Reach 7 |
|----------|---------|

| Particle Class | Particle Size (mm) | Number | Total % | Cumulative % |
|----------------|--------------------|--------|---------|--------------|
| Silt/Clay | < .062 | | 0.00 | 0.00 |
| VFS | .062-.125 | | 0.00 | 0.00 |
| FS | .125-.25 | | 0.00 | 0.00 |
| MS | .25-.50 | | 0.00 | 0.00 |
| CS | .50-1.0 | 2 | 2.00 | 2.00 |
| VCS | 1.0-2.0 | | 0.00 | 2.00 |
| VFG | 2-4 | | 0.00 | 2.00 |
| FG | 4-6 | 2 | 2.00 | 4.00 |
| FG | 6-8 | 3 | 3.00 | 7.00 |
| MG | 8-12 | 3 | 3.00 | 10.00 |
| MG | 12-16 | 3 | 3.00 | 13.00 |
| CG | 16-24 | 7 | 7.00 | 20.00 |
| CG | 24-32 | 3 | 3.00 | 23.00 |
| VCG | 32-48 | 8 | 8.00 | 31.00 |
| VCG | 48-64 | 9 | 9.00 | 40.00 |
| SC | 64-96 | 21 | 21.00 | 61.00 |
| SC | 96-128 | 12 | 12.00 | 73.00 |
| LC | 128-192 | 11 | 11.00 | 84.00 |
| LC | 192-256 | 6 | 6.00 | 90.00 |
| SB | 256-384 | 9 | 9.00 | 99.00 |
| SB | 384-512 | 1 | 1.00 | 100.00 |
| MB | 512-1024 | | 0.00 | |
| LB | 1024-2048 | | 0.00 | |
| VLB | 2048-4096 | | 0.00 | |
| VLB | > 4096 | | 0.00 | |
| | BEDROCK | | 0.00 | |

Reach 7, Site 3 Chart 1



Wigwam River, Reach 9 Pebble Count

| | |
|----------|--------|
| Station: | Site 4 |
|----------|--------|

| Particle Class | Particle Size (mm) | Number | Total % | Cumulative % |
|----------------|--------------------|--------|---------|--------------|
| Silt/Clay | < .062 | | 0.00 | 0.00 |
| VFS | .062-.125 | | 0.00 | 0.00 |
| FS | .125-.25 | | 0.00 | 0.00 |
| MS | .25-.50 | | 0.00 | 0.00 |
| CS | .50-1.0 | 1 | 1.00 | 1.00 |
| VCS | 1.0-2.0 | 1 | 1.00 | 2.00 |
| VFG | 2-4 | 1 | 1.00 | 3.00 |
| FG | 4-6 | 1 | 1.00 | 4.00 |
| FG | 6-8 | | 0.00 | 4.00 |
| MG | 8-12 | 1 | 1.00 | 5.00 |
| MG | 12-16 | 1 | 1.00 | 6.00 |
| CG | 16-24 | 2 | 2.00 | 8.00 |
| CG | 24-32 | 3 | 3.00 | 11.00 |
| VCG | 32-48 | 4 | 4.00 | 15.00 |
| VCG | 48-64 | 4 | 4.00 | 19.00 |
| SC | 64-96 | 8 | 8.00 | 27.00 |
| SC | 96-128 | 5 | 5.00 | 32.00 |
| LC | 128-192 | 20 | 20.00 | 52.00 |
| LC | 192-256 | 5 | 5.00 | 57.00 |
| SB | 256-384 | 11 | 11.00 | 68.00 |
| SB | 384-512 | 12 | 12.00 | 80.00 |
| MB | 512-1024 | 15 | 15.00 | 95.00 |
| LB | 1024-2048 | 5 | 5.00 | 100.00 |
| VLB | 2048-4096 | | 0.00 | |
| VLB | > 4096 | | 0.00 | |
| | BEDROCK | | 0.00 | |

Reach 9, Site 4 Chart 1

